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This section evaluates the effects and benefits of the proposed project on coho salmon, steelhead, and Chinook salmon within the action area in the Russian River watershed. Evaluation criteria outlined in Appendix C are applied to evaluate components of the proposed project described in Section 4.

Section 5.1 assesses the effects of flood control and hydroelectric facility operations. Operation and maintenance activities at Coyote Valley Dam and Warm Springs Dam are evaluated.

Section 5.2 evaluates the effects of operation and maintenance activities related to the diversion facilities and the water supply and transmission system.

Section 5.3 evaluates the effects of the proposed water management. Effects of the Flow Proposal on flow, water temperature, and DO are evaluated. Effects of additional measures proposed as part of water management are also evaluated. Section 5.3 also assesses the effects of proposed water management on the Estuary. The effects of the proposed Estuary management, including a change in the artificial breaching program, are evaluated.

Section 5.4 evaluates the effects of the proposed channel maintenance activities. Section 5.5 evaluates the effects of restoration and conservation actions.

Section 5.6 evaluates the effects of the proposed fish production facilities. Programs proposed for steelhead and coho salmon, as well as future programs for steelhead and Chinook salmon, are assessed.

Section 5.7 provides a summary of effects.

5.1 FLOOD CONTROL OPERATIONS AND HYDROELECTRIC OPERATIONS

This section examines the effects of Warm Springs and Coyote Valley dams' flood control operations on coho salmon, steelhead, and Chinook salmon in order to characterize their influences on salmonid populations and habitats. The effects of hydroelectric operations at Warm Springs Dam are also discussed in Section 5.1.4.

Flood control operations at Warm Springs and Coyote Valley dams affect water quality, flow regimes, and channel geomorphology in the Russian River and Dry Creek. During flood control operations and dam maintenance activities, flow release rates are adjusted at the dams. The flow-rate adjustments may either decrease or increase flow rates. The rate of change is attenuated in a downstream direction in both Dry Creek and the mainstem Russian River.

Flood control operations at Coyote Valley and Warm Springs dams may affect salmonids in various ways. Potential issues of concern include:

- Changes in turbidity
- Effects on channel geomorphology
  - Scour of spawning gravels
  - Streambank erosion
  - Channel maintenance/geomorphology
- Ramping rates and flow recessions

5.1.1 Flood Control and Water Quality

Flood control operations during the winter runoff period do not have a strong influence on temperature or DO conditions, but do have the potential to effect the amount of turbidity in the Russian River and Dry Creek.

Ritter and Brown (1971) conducted the only known turbidity study in the Russian River associated with the operational effects of Coyote Valley Dam. Land-use changes and development in the Russian River watershed may have altered the sources and amount of turbidity in the Russian River since the Ritter and Brown study was conducted. However, this BA addresses only turbidity associated with operation of Coyote Valley and Warm Springs dams, and does not address other sources of turbidity that may occur in the watershed.

During storm runoff events, sediment naturally enters Lake Mendocino and Lake Sonoma, and finer sediment particles often remain suspended in the water column. During and after storm events, turbid water may be released from Coyote Valley Dam for several days until high flows begin to recede from the flood peak in the downstream channel (Ritter and Brown 1971).

Inflow to Lake Mendocino contains a much higher level of turbidity than inflow to Lake Sonoma (USACE 1986a). Because Lake Mendocino inflow has a relatively short residence time compared with Lake Sonoma, much of the suspended sediment does not settle out. Therefore, flow releases from Coyote Valley Dam are more likely to influence downstream water quality. Historically, Dry Creek has had the least persistently turbid water compared with the Russian River (Ritter and Brown 1971). As tributaries downstream of the dams contribute suspended sediment and streamflow to the mainstem Russian River and Dry Creek, the relative proportion of turbidity originating from flood control activities diminishes farther downstream.

Turbidity associated with high-flow releases is due to fine sediment particles (silts and clays) held in suspension. It is unlikely that much of this fine sediment will settle out in the bed of downstream channels. Silt and clays are readily transported in suspension as wash-load (Reid et al. 1997), and much of this material is either deposited in long-term sediment storage features such as terraces, floodplains, natural river levees, and bars, or is completely transported through the river channel. Thus, turbidity associated with flood control releases is not expected to have a great influence on physical habitat conditions such as spawning gravels, riffles, or pools. Persistent turbidity, however, could affect behavioral activities such as abandonment of cover or short-term reduction in feeding rates. For example, Berg and Northcote (1985) found that feeding and territorial behavior of juvenile coho salmon are disrupted by short-term exposures (2.5 to 4.5 days) to turbid water (up to 60 NTU).

The Water Quality Control Plan for the North Coast Region sets a standard for turbidity as:

> *Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.*

The turbidity of water releases from Coyote Valley and Warm Springs dams depends on the duration and intensity of flows into the flood control reservoirs. Ritter and Brown (1971) measured turbidity levels at locations above and below Lake Mendocino in the Russian River and found that periods of persistent water turbidity (greater than 20 mg/l) appear to be generally the same above and below Coyote Valley Dam (Table 5-1). They concluded that water in Lake Mendocino remains turbid about as long as water entering the reservoir remains turbid, and that water releases at Coyote Valley Dam will remain turbid until the water flowing into the lake becomes clear. Based on the Ritter and Brown (1971) study, it appears that discharges from Coyote Valley Dam are within the 20 percent turbidity criteria for the North Coast Region.

Table 5-1 Periods of Persistent Turbidity (> 20 mg/l), East Fork Russian River, 1965 to 1968

	1965	1966	1967	1968
East Fork Russian River near Calpella	Dec. 20-July 16	Nov. 15-May 20	Nov. 15-May 19	Nov. 30-Apr. 15
East Fork Russian River near Ukiah	Dec. 21-May 19	Nov. 17-July 19	Nov. 18-June 7	Dec. 2-Apr. 19

Source: Ritter and Brown (1971)

The Russian River is naturally turbid during the winter and spring runoff. If Lake Mendocino did not exist, the turbid water that enters the lake would have flowed down the East Fork unobstructed and the turbidity of Russian River water would have increased between storm events. Instead, Lake Mendocino interrupts the turbid flows on the East Fork. Thus, when releases from the lake are low for several days following flood flow releases, the water on the Russian River becomes clear (Ritter and Brown 1971). This condition probably would not have occurred if Coyote Valley Dam did not exist, indicating that flood control operations are unlikely to increase turbidity in the mainstem or to affect listed salmonids.

5.1.2 EFFECTS OF FLOOD CONTROL OPERATIONS ON CHANNEL GEOMORPHOLOGY

Flood control operations attenuate floods by storing stormwater discharge in reservoirs. By releasing the stored water more slowly into the Russian River, flood operations damp-out peak flows and increase the duration of moderate flows in mainstem channels.

Flood control activities result in a change in the natural hydrograph, which may alter the geomorphic function of the system. *Interim Report 1* (ENTRIX, Inc. 2000a) examined flood control activities in the Russian River and identified three potential effects of flood control operations on channel geomorphology: the scour of salmonid redds, increased streambank erosion, and the reduction of channel maintenance flows. Appendix C provides evaluation criteria and analysis methodology for these studies.

5.1.2.1 Scour of Spawning Gravels

While flood control activities at Warm Springs and Coyote Valley dams reduce the magnitude of flood peaks in the Russian River, the magnitude and duration of flood releases may still be sufficient to mobilize the streambed, resulting in the loss of incubating embryos. The potential for redd scour was evaluated in three reaches, between Cloverdale and Ukiah (Upper Russian River), in the Alexander Valley (Middle Russian River), and in Dry Creek. Chinook salmon and steelhead typically spawn in the Upper Russian River, while all three species may spawn in Dry Creek. Chinook salmon spawning was documented in Dry Creek in 2003 (A. Harris, SCWA, pers. comm. 2003). The analysis showed that on the mainstem Russian River, redd scour can occur during high winter flows in the absence of flood control releases and that the frequency of redd scour increases with distance downstream from the dam.

The potential for redd scour was estimated by determining the percent of flows in each reach, over a 36-year period (1960 to 1995), that resulted in the mobilization of spawning gravels sufficient to expose the egg pocket of the redd. It is expected that the flood flow regime developed from this 36-year period of record would be similar to the flood flow regime in the future under the proposed project. Each species uses a different size of spawning gravel and each size of spawning gravel responds differently to floods. To characterize gravel, geomorphologists use the median size of gravel, D50, as measured by the diameter of a particle. The D50 means that 50 percent of the population of particle sizes (i.e., spawning gravel bed material) is equal to or finer than the representative particle diameter. Chinook salmon spawn in gravels with a D50 of 36 mm, steelhead spawn in gravels with a D50 of 22 mm, and coho salmon spawn in gravels with a D50 of 16 mm. These D50 are based on a compilation of spawning gravel particle sizes reported from numerous studies on streams throughout the western states (Kondolf and Wolman 1993). From here on, this report uses the terms “Chinook spawning gravels,” “steelhead spawning gravels,” and “coho spawning gravels” to refer to a particle size composition of streambed material with the respective D50 listed above.

Scour events that occur later in the spawning and incubation season are more detrimental than those that occur earlier because they have the greatest potential to scour the most redds and incubating alevins. Late-season high flows that disrupt spawning gravels with incubating eggs will likely have a greater adverse effect on reproductive success for that year's class.

Table 5-2 presents the results of the spawning gravel scour analysis. A score of 1 indicates the highest frequency of scour, and a score of 5 indicates the lowest frequency of scour. Appendix C presents a more detailed explanation of the evaluation criteria and analysis.

Table 5-2 Spawning Gravel Scour Scores (Percent), by Location, for a 36-Year Period (1960 to 1995)

Score*	Ukiah to Alexander Valley (near Cloverdale)		Alexander Valley		Dry Creek		
	Steelhead	Chinook	Steelhead	Chinook	Steelhead	Chinook	Coho
5	2.8	2.8	2.8	11.1	22.2	47.2	13.9
4	55.6	0	5.6	11.1	16.7	11.1	5.6
3	41.7	97.2	33.3	63.9	33.3	27.8	16.7
2	0	0	58.3	13.9	27.8	13.9	22.2
1	0	0	0	0	0	0	41.7

*Score of 5 indicates least scour, 1 indicates most scour.

Upper Reach Russian River

Table 5-2 summarizes the results of the spawning gravel scour evaluation between Ukiah and Cloverdale. The evaluation indicates steelhead gravels were relatively stable. A total of 26 cross-sections were analyzed in this reach for both steelhead and Chinook salmon. Of these 26, 9 cross-sections (35 percent of the total 26) never showed initiation of movement for steelhead gravel sizes. Therefore, the assigned scores were always better than 1 or 2. In one of the 36 years analyzed (e.g., 2.8 percent of the time), steelhead gravels at no more than 10 cross-sections (e.g., 38 percent of the total 26) experienced initiation of motion, thus earning a score of 5. In 55.6 percent of the years analyzed (e.g., 20 years of the 36 evaluated), 65 percent of the cross-sections (e.g., up to 17 cross-sections) experienced scour, earning a score of 4. For 41.7 percent of the 36 years evaluated (e.g., 15 years), up to 17 cross-sections experienced scour during the latter part of the incubation season (May 1–May 30), earning a score of 3. In this case, the lower score of 3 is assigned because the scour occurs during the latter part of the incubation season. This is in contrast to those years when a score of 4 was assigned, even though the same number of cross-sections, 17, experienced scour with a similar frequency over the 36-year-period analyzed.

Chinook salmon spawning gravels (i.e., the median-size gravel used by Chinook salmon) were moved more frequently than steelhead spawning gravel, even though Chinook salmon spawning gravels are larger and less apt to be mobilized. This is because Chinook salmon spawn earlier in the year than steelhead, so that more scouring events take place after Chinook salmon have completed spawning, subjecting eggs to a greater risk of scour. Therefore, the potential for negative effects on incubation are greater.

Of the 26 cross-sections, 16 never showed initiation of movement for the gravel sizes Chinook salmon use. Therefore, the scores earned were always better than 1 or 2. However, in 97.2 percent of the years analyzed (35 out of 36 years), 10 of the 26 cross-sections (38 percent) were scoured during the incubation season (February 1–March 30), earning a score of 3.

In general, Chinook salmon spawn only through January, while their incubation period extends through March. High flows are frequent in February and March where redd loss cannot be replaced by subsequent spawning. Thus, scour of Chinook salmon spawning gravels occurs more frequently than steelhead during their sensitive incubation period, indicating that Chinook salmon redds are more susceptible to scour from high winter flows.

Middle Reach Russian River

Table 5-2 summarizes the data for the Alexander Valley or Middle Reach. A total of 30 cross-sections were analyzed for both Chinook salmon and steelhead. Redd scour was more frequent in the Middle Reach than in the Upper Reach, due to flow accretion from downstream tributaries.

Of the 30 cross-sections, steelhead spawning gravels at only 1 cross-section never experienced scour over the range of flows evaluated in the 36-year period of record. For 58 percent of the years (e.g., 21 years), steelhead spawning gravels were assigned a score of 2. The score of 2 is a result of scour at 29 cross-sections during the December 1–April 30 period, although no scour occurred during the later incubation period (May 1–May 31). For 33 percent of the years analyzed (e.g., 12 years), up to 22 cross-sections out of 30 (75 percent) experienced scour during the earlier spawning season (December 1–April 30), earning a score of 3. There were 2 years (5.6 percent frequency) when scour occurred at less than one-half of the 30 cross-sections, earning a score of 4, and only 1 year (2.8 percent) when less than 25 percent of the cross-sections (up to 7 cross-sections) were scoured, earning a score of 5.

Chinook salmon spawning gravel scores indicate more stable conditions. Of the 30 cross-sections analyzed, spawning gravels at 25 percent (8) never experienced scour, so there were no years that received a score of 1. In 13.9 percent of the years (e.g., 5 years), scour took place at up to 22 cross-sections in the later incubation season (February 1–March 31), earning a score of 2. Scour at up to 22 cross-sections during the earlier spawning season (November 1–January 31) earned a score of 3. A score of 3 was also earned when scour occurred at no more than 15 cross-sections (50 percent) during the later incubation period. In combination, a total of 64 percent of the years analyzed (23 years), resulted in a score of 3. A score of 4 was earned in 11 percent of the years (4 years), indicating scour at up to 15 cross-sections during the earlier spawning season, and a score of 5 was earned in 11 percent of the years, indicating scour at 6 or fewer cross-sections.

While both spawning gravel types scored lower in the Middle Reach mainstem than in the Upper mainstem, Chinook salmon did better in the Alexander Valley than steelhead. This is likely because the smaller steelhead gravels are much less able to withstand scouring under a high-flow regime. Thus, even though steelhead spawn later than Chinook salmon, this advantage is not enough to overcome the scouring effects of the high-velocity flows in the reach. Overall, the larger gravel preferred by Chinook salmon is more resilient to high winter flows in the Middle Russian River mainstem than the smaller steelhead spawning gravel.

Dry Creek

Table 5-2 summarizes the data for Dry Creek. On Dry Creek, flood control operations were evaluated for scour of spawning gravels for all three salmonid species. Significant scour of steelhead and Chinook salmon gravels rarely occurs in Dry Creek. There were 112 cross-sections analyzed on Dry Creek. Steelhead spawning gravels earned a score of 3 or higher in 72 percent of the years, while Chinook spawning gravels received a score of at least 3 or higher in 86 percent of the years.

For steelhead, 27.8 percent of the years analyzed (10 years) received a score of 2, indicating that gravels at up to 108 cross-sections out of 112 (96 percent) experienced scour during the early part of the spawning season. Up to 75 percent of the cross-sections (84 out of 112) experienced scour during the early part of the spawning season (December 1–April 30) in 12 of the years evaluated in the 36-year period of record, earning a score of 3 (33.3 percent). Up to 46 percent of the cross-sections (52 out of 112) scoured in 6 of the years evaluated (16.7 percent), earning a score of 4. Up to 22 percent of the cross-sections (25 out of 112) scoured in 8 of the years evaluated (22.2 percent), earning a score of 5. In almost all years, gravels were never scoured at more than 21 cross-sections during the later incubation period.

For Chinook salmon, 47 percent of the years analyzed (17 years) received a score of 5, indicating that up to 21 cross-sections out of 112 (19 percent) experienced scour. A score of 4 was received in 11 percent of the years (4 years), indicating scour at up to 46 cross-sections (41 percent of the 112 evaluated) during the early part of the spawning season. A score of 2 was earned in 13.9 percent of the years evaluated (5 years), indicating scour at up to 108 cross-sections (96 percent of the 112). None of these scour events occurred during the later incubation season so therefore no years received a score of 1.

Coho spawning gravels faired much more poorly, due to their smaller size and the fact that coho salmon spawn in November through January. Model results indicated that coho redds would have been lost or severely depleted (scores of 1 or 2) in most of the transects in almost 64 percent of the years. The score of 1 indicates that 98 percent of the cross-sections analyzed experienced scour during the later incubation period (February 1–February 28), for 42 percent of the years evaluated. The score of 2 indicates that in 22 percent of the years evaluated, 98 percent of the cross-sections were scoured during the earlier part of the spawning period (December 1–January 31). Coho salmon redds would have faired well (scores of 4 or 5) in almost 20 percent of the years. A score of 5 indicates that up to 25 percent of the cross-sections evaluated experienced scour, and a score of 4 indicates that up to 49 percent of the cross-sections experienced scour during the earlier spawning season. Considering that the streambed should be periodically entrained to flush and transport fine sediments and thereby maintain good-quality spawning gravels, the scores probably indicate a reasonably good balance between streambed mobilization and spawning gravel stability for successful reproduction of Chinook salmon, and an acceptable balance for steelhead. Frequent mobilization of the streambed (by bankfull discharges occurring on average every 1 to 2 years) and by larger floods (exceeding 3- to 5-year annual maximums) are important attributes of adjustable channels that are needed to maintain a balanced sediment budget over the long-term (McBain and Trush 1997). Without a balanced sediment budget, the channel will experience vertical bed instability, either aggradation or degradation.

Coho spawning gravels in Dry Creek are scoured frequently and may result in low incubation success. Given the present geomorphology of Dry Creek, scour of coho spawning gravels would occur in the absence of flood control operations. The narrowing and straightening of the channel from riparian encroachment and channel downcutting may exacerbate scour.

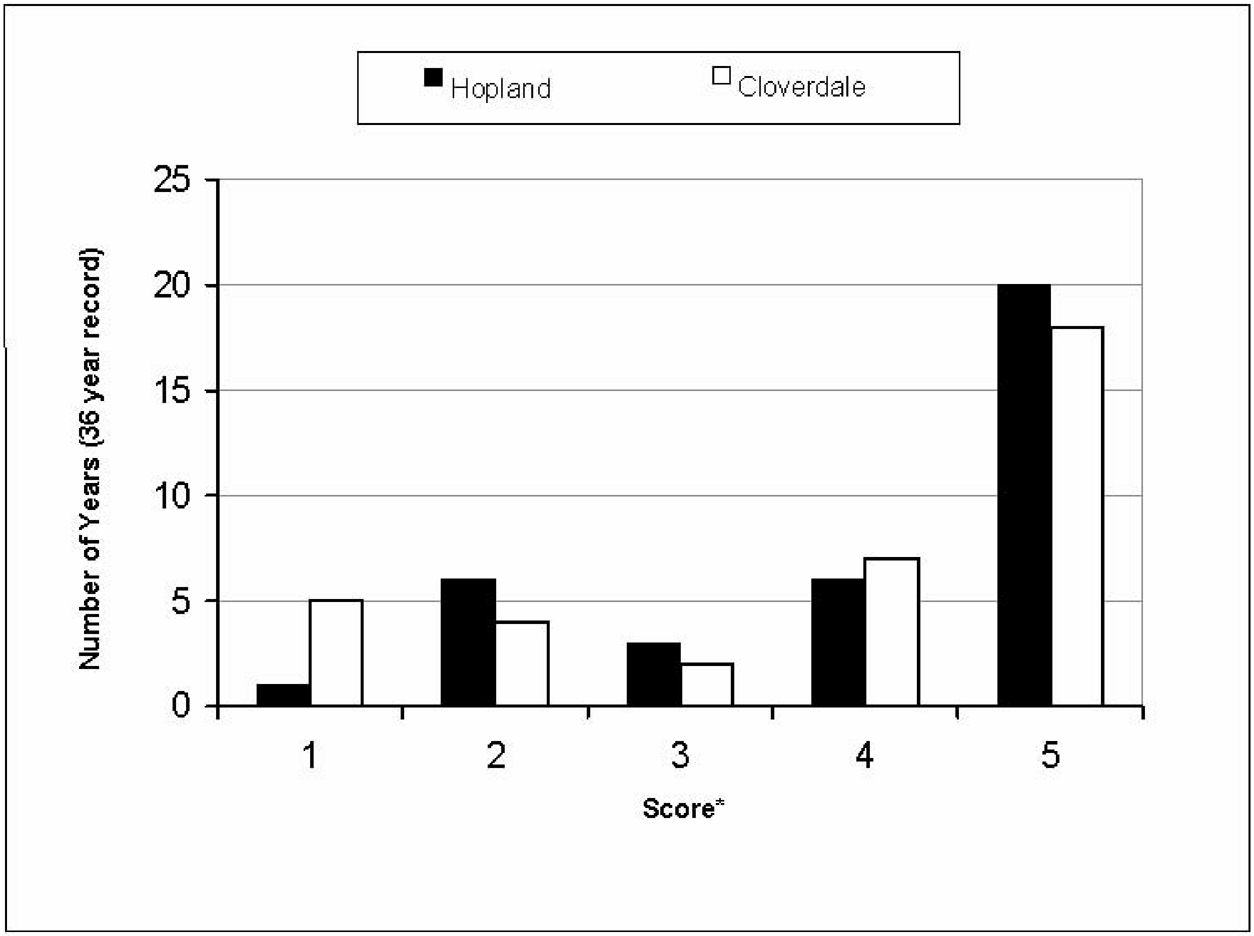
5.1.2.2 Streambank Erosion

Sustained releases of flood flows have been cited as a potential cause of streambank instability on both Dry Creek and the mainstem Russian River. Streambank erosion can temporarily increase sediment loads and reduce habitat complexity. Prolonged discharges in excess of 2,500 cfs are believed to be a cause of accelerated bank erosion on Dry Creek (USACE 1999a). For the mainstem Russian River, there are also no reports that specify which mainstem reaches are subject to erosion, except that "high sustained releases erode the river bank for miles downstream" (USACE 1999a). At flow thresholds of 6,000 cfs at Hopland and 8,000 cfs at Cloverdale, bank erosion is assumed to occur. Appendix C presents the basis for these conclusions.

Mainstem Russian River

Using threshold values of 6,000 cfs at Hopland and 8,000 cfs at Cloverdale, streamflows above these values were tallied on an annual basis for water years 1960 to 1995. The greater the number of days that exceeded these thresholds in a given year, the greater the likelihood of streambank erosion and the lower the score. Figure 5-1 is a frequency histogram showing these scores. Most years receive a score of 5 at both locations evaluated. At Hopland, 80 percent of the 36-year period of record (29 years) received a score of 3 or better. At Cloverdale, 75 percent of the 36-year period of record (27 years) received a score of 3 or better.

It is noteworthy that on many of the days when flows exceeded the erosion threshold, discharge from Coyote Valley Dam was low. For example, in 1995 there were 12 days when flows exceeded the 6,000-cfs erosion threshold, but the release from Coyote Valley Dam never exceeded 600 cfs, and was usually only 35 cfs. At Cloverdale, there were 21 days when flows exceeded the 8,000-cfs erosion threshold. But on only three of those days, releases from Coyote Valley Dam increased the total downstream discharge.



* Number of years receiving calculated score over the period of record analyzed. Lower scores are indicative of years with relatively greater number of bank erosion events; higher scores indicate relatively fewer bank erosion events, for the number of years shown in the graph.

Figure 5-1 Frequency Histogram of Bank Erosion Scores on Mainstem Russian River, 1960 to 1995

To minimize bank erosion, flood control operations are often timed so that reservoir outflows constitute a relatively insignificant portion of the total streamflow at Hopland or Cloverdale. The analyses indicate that flood operations at Coyote Valley Dam do not cause prolonged flows above the threshold at which streambank instability and erosion begin in the Upper and Middle Reaches of the Russian River.

Dry Creek

Streambank erosion on Dry Creek occurs when sustained flows exceed 2,500 cfs (USACE 1999a). To assess the effects of flood control operations on erosion, streamflows above 2,500 cfs were tallied on an annual basis for the water years 1960 to 1995. The greater the number of days that exceed 2,500 cfs in a given year, the greater the likelihood of streambank erosion and the lower the score.

Table 5-3 shows bank erosion scores for two Dry Creek locations (immediately below Warm Springs Dam and near Geyserville) by water year. The Geyserville location is below the Pena Creek confluence, which represents the most significant tributary input on the Dry Creek system. Figure 5-2 is a frequency histogram showing the Dry Creek bank erosion scores.

As shown in Table 5-3, a score of 5 was assigned to about half of the years analyzed (18 of 36 years) near Geyserville, indicating that flows did not exceed 2,500 cfs more than 3 days per year. However, a score of 1 was assigned to 10 of the 36 years in the water record. Thus, in approximately 28 percent of the years, flows exceeded 2,500 cfs for more than 16 days and streamflow conditions were highly conducive to bank erosion. Inspection of the flow records indicates that in many years when the score is 1, there are at least 5 consecutive days when flows exceed 2,500 cfs, indicating prolonged high-flow conditions.

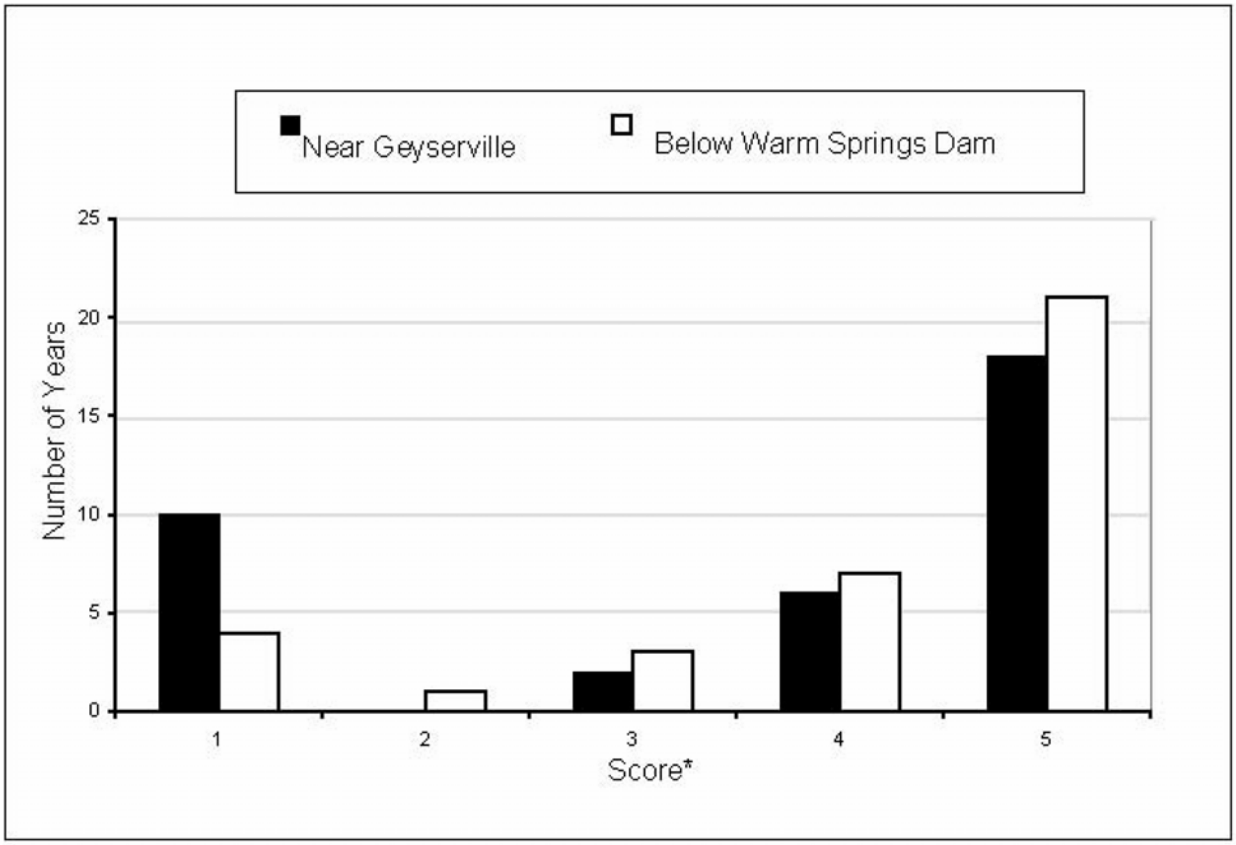
It is noteworthy that on many days when flows exceeded the erosion threshold near Geyserville, discharge from Warm Springs Dam was low (the “Near Geyserville” location is the USGS gaging station downstream of the Pena Creek confluence). For example, inspection of the modeled flow records indicates that in water year 1983, there were 33 days when flows exceeded the 2,500-cfs erosion threshold near Geyserville; but on 13 of those days, the release from Warm Springs Dam was no greater than 120 cfs. Flood control operations are often timed so that reservoir outflows during prolonged peak streamflow conditions downstream are a relatively insignificant contributor to total flow and bank erosion.

Model simulations of the 318 days when flows exceeded the 2,500-cfs erosion threshold show there were 114 days (36 percent of the time) when natural flow accretion below Warm Springs Dam was greater than 2,500 cfs. Flow releases were either very low or smaller than natural flow accretion below the dam so that the erosion threshold would have been exceeded regardless of flood operations at Warm Springs Dam. Therefore, the evaluation criteria may overstate the influence of flood control operations at Warm

Table 5-3 Number of Days with Flow Exceeding 2,500 cfs on Dry Creek, and Score, for 36-Year Period

Water Year	Days Exceeding 2,500 cfs		Score*	
	Below Warm Springs Dam	Near Geyserville	Warm Springs Dam	Near Geyserville
1960	3	3	5	5
1961	0	0	5	5
1962	4	7	4	4
1963	5	6	4	4
1964	0	0	5	5
1965	10	16	3	1
1966	4	4	4	4
1967	9	8	3	3
1968	0	0	5	5
1969	19	18	1	1
1970	26	31	1	1
1971	1	5	5	4
1972	0	0	5	5
1973	7	18	4	1
1974	17	33	1	1
1975	3	7	5	4
1976	0	0	5	5
1977	0	0	5	5
1978	0	6	5	4
1979	0	2	5	5
1980	12	21	2	1
1981	0	0	5	5
1982	7	18	4	1
1983	10	36	3	1
1984	0	3	5	5
1985	0	0	5	5
1986	5	10	4	3
1987	0	0	5	5
1988	0	1	5	5
1989	0	0	5	5
1990	0	0	5	5
1991	0	0	5	5
1992	0	0	5	5
1993	7	25	4	1
1994	0	2	5	5
1995	33	39	1	1

*High scores indicate streamflow conditions were not conducive to bank erosion, while low scores indicate they were.



* Number of years receiving calculated score over the period of record analyzed. Lower scores are indicative of years with relatively greater number of bank erosion events; higher scores indicate relatively fewer bank erosion events for the number of years shown in the graph.

Figure 5-2 Frequency Histogram of the Dry Creek Bank Erosion Scores, 1960 to 1995

Springs Dam on downstream bank erosion. Flood operations at the dam do not cause the prolonged flows above the threshold that initiated streambank instability and erosion in most years.

5.1.2.3 Channel Maintenance and Geomorphology

Flow regulation during flood control operations changes the hydrologic regime, which can cause a geomorphic response. Most channel adjustments, however, likely take place within a few decades after dam construction (Mount 1995).

Adequate flows are periodically needed in a natural channel to maintain channel geomorphic conditions (McBain and Trush 1997). High flows mobilize the streambed and transport sediments, creating bed forms and cleaning fines from the streambed. Such flows are necessary to provide suitable spawning and rearing conditions for salmonids. However, such flows can also scour spawning gravels. Ideally, there is a balance between periodic mobilization of the streambed, sediment transport processes, and stability of spawning gravels. Lack of peak flows can reduce spawning success by increased sedimentation, while frequent peak flows can reduce spawning success through scour.

Land uses and development in the Russian River watershed, including gravel extraction, agricultural practices, and urbanization, have also influenced channel geomorphic conditions (Simons & Associates 1991). Distinguishing the effects of flood control operations from these land-use effects can be problematic.

For instance, on the mainstem Russian River gravel mining operations have altered channel geomorphic conditions between Healdsburg and Ukiah. This has led to almost 16 feet of channel-bed degradation in the East Fork Russian River and approximately 2 feet of bed degradation in the Alexander Valley near Cloverdale (EIP 1993).

Table 5-4 presents scoring criteria based on the number of years in which the maximum flood discharge exceeds the value required to maintain channel geomorphology. A single score is given for the entire period of record (1960 to 1995), because any single year alone does not encompass a sufficiently long time-period to assess whether flood control operations are adequate to maintain channel geomorphic conditions. On average, the natural channel-forming flow should occur in 2 out of every 3 years (Dunne and Leopold 1978). Conditions meeting this criterion (i.e., 19 to 24 times in 36 years) were assigned a score of 5. When the channel-forming flow occurs less frequently, lower scores are applied. Channel-forming flows that occur less than 10 percent of the time (i.e., less frequently than 1 out of every 10 years) receive a score of 1, and if the natural channel-forming flow is never equaled or exceeded, the score is 0. The scoring applies equally to coho salmon, steelhead, and Chinook salmon.

Table 5-4 Scoring Criteria for Maintenance of Channel Geomorphic Conditions

Score*	Annual Flood Exceedance Frequency	Number of Years per 36-Year Period of Record[a]
5	51-66%	19-24
4	36-50%	14-18
3	21-35%	8-13
2	11-20%	5-7
1	1-10%	4 or less
0	0%	0

[a] Multiple channel-forming flows that may occur in a single year are counted as one occurrence for that year.
* Score of 5 is greatest, 1 is least.

Mainstem Russian River

The hydrologic record developed from model simulations for regulated flow conditions using the period 1960-1995 was evaluated to determine the frequency of occurrence of the channel-forming flow. This flow (as an average one-day discharge) was estimated to be 9,500 cfs at Hopland, 14,000 cfs at Cloverdale, and 21,000 cfs at Healdsburg (see Appendix C).

Table 5-5 shows the number of flood events that are predicted to equal or exceed channel-forming flows at each location (years which do not achieve the channel-forming flow are not shown), and the resulting score based on the criteria in Table 5-4. The score is a function of the number of years between 1960 and 1995 that have at least one flood event as an annual maximum that equals or exceeds the channel-forming discharge.

The results show that at Hopland and Cloverdale, at least one channel-forming discharge occurs in 50 percent of the 36 years modeled (18 times out of 36 years). Therefore, a score of 4 is given to these locations, indicating that the flood regime on the Upper Reach Russian River is adequate to maintain channel geomorphic conditions. At Healdsburg, the channel-forming discharge is exceeded in 21 of the 36 years assessed, so this channel region is assigned a score of 5. This reflects the fact that peak flow events at Healdsburg are relatively unaffected by flood control operations at Coyote Valley Dam.

Dry Creek

The hydrologic record developed from model simulations for regulated flow conditions using the period 1960-1995 was evaluated to determine the frequency of occurrence of the channel-forming flow. The channel-forming discharge (as an average daily flow) on Dry Creek was estimated to be 7,000 cfs near Geyserville (below the Pena Creek tributary confluence). Table 5-6 shows the number of simulated flood events that equal or exceed the channel-forming flow (years that do not achieve the channel-forming flow are not shown). Results show 6 years that equal or exceed the channel-forming discharge on Dry Creek. This represents a 17 percent frequency for the 36-year period of record, and therefore the score is 2. This is a low score, indicating that flood control operations have

Table 5-5 Tally of Flow Events Exceeding Channel-Forming Discharge (as Average Daily Flow) and Score for Mainstem Russian River

Water Year	Hopland 9,500 cfs	Cloverdale 14,000 cfs	Healdsburg 21,000 cfs
1960	1	2	2
1962	0	1	3
1963	1	2	2
1965	6	6	5
1966	2	2	1
1967	1	1	1
1969	4	4	2
1970	7	5	7
1971	2	2	3
1973	1	0	3
1974	3	4	5
1975	1	0	1
1978	4	3	5
1980	3	4	5
1982	5	4	6
1983	6	5	9
1984	0	2	1
1986	1	6	7
1991	0	0	1
1993	2	3	3
1995	5	9	9
Number of Water Years with Flow Event that Equals or Exceeds Channel-Forming Discharge	18	18	21
Score*	**4**	**4**	**5**

*Score criteria based on Table 5-4.

Table 5-6 Tally of Flow Events Exceeding Channel-Forming Discharge on Dry Creek

Water Year	Near Geyserville 7,000 cfs
1970	4
1971	1
1973	1
1974	2
1978	1
1980	2
Number of Water Years with Flow Event that Equals or Exceeds Channel-Forming Discharge	6
Score*	**2**

*Score criteria based on Table 5-4.

reduced the frequency of channel-forming flows in Dry Creek and may not be adequate to maintain overall channel geomorphic conditions as represented by the historic channel form.

Immediately below Warm Springs Dam, the channel-forming discharge (as an average daily flow) is 5,000 cfs. There were no simulated flows over the period of record that equaled or exceeded the channel-forming discharge. Therefore, the score for the channel reach between the dam and Pena Creek is 0, indicating potentially inadequate channel maintenance flow associated with the historic pre-dam channel morphology of Dry Creek.

Despite the lack of pre-dam geomorphic flows, the spawning gravels in Dry Creek appear to be suitable for use by coho salmon, steelhead, and Chinook salmon. No evidence of excessive sedimentation that would inhibit incubation success has been noted, and successful spawning by Chinook salmon and steelhead have been reported.

As noted in Section 2, Dry Creek has undergone some geomorphic change as a result of the construction of Warm Springs Dam, agricultural practices, and gravel mining. Significant channel geomorphic changes were apparently already underway on Dry Creek prior to the construction of Warm Springs Dam. USACE conducted a study that concluded that gravel mining on Dry Creek and on the mainstem Russian River had caused approximately 10 feet of incision along the 14-mile channel length by the mid-1970s (USACE 1987). The channel incision on Dry Creek initiated lateral instability and subsequent bank erosion so that channel width had increased from approximately 90 feet to over 450 feet in some locations in the 1970s (USACE 1987). The 1987 study concluded that it was unlikely that further channel degradation would occur, but that continued lateral instability and erosion of the incised channel banks were likely.

Downstream of Warm Springs Dam, channel geomorphology has already changed substantially, not only in response to flow regulation associated with the dam, but to historic pre-dam gravel mining and other land-use activities in the watershed. It is likely continuing to adjust towards a new equilibrium. With a narrower, incised low-flow channel, and vegetation encroachment, the pre-dam channel-forming flows may not be appropriate for Dry Creek in its new configuration. Flows in Dry Creek are still sufficiently high to mobilize the bed and thus avoid adverse effects associated with sedimentation of the streambed.

5.1.2.4 Effects of Ramping Rates during Flood Control Operations on Listed Fish Species

Ramping rates refer to the rate of change in water releases from flood control reservoirs into mainstem channels. These rates are an important component of flood control operations, because salmonids can become stranded in downstream channels if flows recede too quickly.

The analysis of ramping rates on the Russian River assumes the effect of ramping at the dams is attenuated approximately 5 miles downstream of Coyote Valley Dam past the confluence with the mainstem Russian River at the Forks, and 1.0 to 1.5 miles downstream of Warm Springs Dam in Dry Creek to near the Pena Creek confluence. The evaluation assesses whether the rates of stage change during ramping operations pose a risk to young salmonids. The evaluation criteria were based on the ramping-rate guidelines developed by Hunter (1992) and the interim ramping criteria developed in consultation with CDFG. The Hunter (1992) guidelines are considered a conservative ramping standard for the Russian River watershed because they were developed on streams located in the Pacific northwest, a hydrologic regime that is dominated by snowmelt processes. In the Russian River drainage, storms naturally result in “flashy” runoff conditions with relatively larger changes in stage compared with snowmelt runoff conditions. The evaluation criteria are discussed further in Appendix C.

Coyote Valley Dam

Hourly flow-release data at Coyote Valley Dam were inspected for 1997 to 1999. Typically, ramping rates were approximately 250 cfs/hr for flows between 1,000 cfs to 250 cfs and only infrequently exceeded this ramping rate. For flows below 250 cfs, ramping rates were generally below 125 cfs/hr and rarely exceeded this rate. Based on the ramping scoring criteria, flood control operations received a score of 4 or better, when a stage change criterion of 0.32 ft/hr was met. On the mainstem Russian River, the ramping performance was evaluated at four cross-sections, located between 3 miles downstream of Coyote Valley Dam and 5 miles below the dam, near the Perkins Street Bridge crossing in Ukiah. There are no existing cross-section surveys further upstream or on the East Fork Russian River. Using a ramping rate of 250 cfs/hr, none of the cross-sectional areas achieved a stage change of less than 0.32 ft/hr (i.e., 100 percent greater than the Hunter criteria). In fact, stage changes were generally 0.5 ft/hr or more, suggesting there is a potential risk of stranding fish in the Upper Russian River mainstem.

Based on these results, a score of 3 was assigned to ramping operations during reservoir releases in the range of 1,000 to 250 cfs (Table 5-7). This score is applicable to steelhead fry and juvenile life-history stages. Chinook salmon and coho salmon do not generally rear in the East Fork.

Table 5-7 Coyote Valley Dam Ramping Scores for High-Reservoir Outflows (1,000 to 250 cfs) during Flood Control Operations

Scoring Category	Criteria	Score
5	Meets 0.16 ft/hr maximum stage change.	
4	Within 100% of 0.16 ft/hr criterion (0.32 ft/hr) for stage change.	
3	Meets interim ramping criterion (250 cfs/hr).	X
2	Exceeds interim ramping criteria up to 50% (375 cfs/hr).	
1	Exceeds interim ramping criteria by greater than 50% (>375 cfs/hr).	

Warm Springs Dam

Stage-discharge relationships generated by the HEC-RAS model (*Interim Report 1,* ENTRIX, Inc. 2000a) were used to evaluate potential ramping effects on salmonids in Dry Creek. Hourly flow-release data were also examined to determine the extent to which reductions in flood control releases occurred within ramping guidelines. Ramping scores are shown in Table 5-8.

Table 5-8 Dry Creek Ramping Scores for High-Reservoir Outflows (1,000 cfs to 250 cfs)

Scoring Category	Criteria	Score
5	Meets 0.16 ft/hr maximum stage change.	
4	Within 100% of 0.16 ft/hr criterion (0.32 ft/hr) for stage change.	
3	Meets 250 cfs/hr ramping criterion.	X
2	Exceeds 250 cfs/hr ramping criteria up to 50% (375 cfs/hr).	
1	Exceeds 250 cfs/hr ramping criteria by greater than 50% (>375 cfs/hr).	

Hourly flow-release data at Warm Springs Dam were inspected for 1997 to 1999. Typically, ramping rates were within 250 cfs/hr for flows between 1,000 cfs to 250 cfs, and only rarely exceeded this ramping rate. Flood control operations receive a score of at least 3. Stage changes during ramping-down were measured at ten cross-sectional areas from Warm Springs Dam to 1.5-mile downstream on Dry Creek. Stage changes associated with a 250-cfs/hr ramping rate exceeded 0.16 ft/hr at all ten cross-sections. HEC-RAS model results indicate that stage changes range from 0.20 to 0.80 ft/hr. The greatest change in stage during ramping always occurred when release flows were low (i.e., between 500 cfs and 250 cfs).

Of the ten cross sections, the four furthest downstream (HEC-RAS model numbers 103 to 106 [*Interim Report 1,* ENTRIX, Inc. 2000a]) generally met the 100-percent stage-change criteria for juveniles (i.e., 0.32 ft/hr), which would merit a score of 4. However, the remaining six cross-sections closest to Warm Springs Dam did not meet the 0.32 ft/hr evaluation criteria. Thus, ramping-down of flow releases in this range pose a low but acceptable risk of stranding for coho salmon, steelhead, and Chinook salmon. Therefore, a final score of 3 is assigned for ramping during reservoir releases in the range of 1,000 cfs to 250 cfs (Table 5-8). This score is applicable to both fry and juvenile lifestages for all three listed fish species.

<u>Ramping Rates for Releases Less Than 250 cfs</u>

The following paragraphs consider ramping rates for flow releases less than 250 cfs for both Coyote Valley Dam and Warm Springs Dam. Evaluation criteria are scored for ramping practices at both dams for periods when fry (salmonids less than 50 mm) are present and when juveniles only are present. Table 5-9 shows the periods when fry may be present for each species. Evaluation criteria are applicable for all three listed fish species in the Russian River and in Dry Creek, as rearing and migration could potentially be affected.

Table 5-9 Times When Fry May Be Present in the Russian River Drainage

Species	Emergence	Fry May Be Present
Coho	Feb. 1 - Mar. 31	Feb. - April
Steelhead	Mar. 1 - May 31	Mar. - June
Chinook	Feb. 1 - Mar. 31	Feb. - April

Under the proposed project, flow ramping rates would be 25 cfs/hr or less at both Coyote Valley and Warm Springs dams when releases are less than 250 cfs.

East Fork and Mainstem Russian River below Coyote Valley Dam

Ramping rates are of particular concern in the mainstem during periods when flows are low, as there is less attenuation of flow recessions. In *Interim Report 1* (ENTRIX, Inc. 2000a), stage changes associated with 25 cfs/hr incremental flow reductions were modeled at four cross-sections in the mainstem from approximately 3 miles below Coyote Valley Dam to 5 miles below the dam near the Perkins Street Bridge crossing in Ukiah. (There are no existing cross-section surveys further upstream or on the East Fork Russian River.) These stage changes were modeled beginning at 250 cfs and progressing to 50 cfs.

At 25 cfs/hr reductions, the 0.16 ft/hr Hunter criterion (1992) is met at most flow intervals in all four of the cross-sections for flow ranges below 250 cfs. Stage changes ranged from 0.04 to 0.36 ft/hr. Therefore, a ramping rate of 25 cfs/hr when flows are below 250 cfs would be protective of young salmonids. A score of 4 is given when only juveniles are present and a score of 3 is given when fry are present (Table 5-10).

At Warm Springs Dam, flows are ramped at a rate of 25 cfs/hr, and a score of 4 is given for the period when only juveniles are present (Table 5-10). The score is 3 when fry are present.

Table 5-10 Evaluation Criteria for Low-Reservoir Outflows (250 cfs to 0 cfs) during Dam Maintenance and Pre-Flood Inspection Periods

Score* Juvenile	Score* Fry	Change in Flow (cfs/hr)	Operations Score
5	5	0-10	
5	4	10-20	
4	3	20-30	Warm Springs Dam Coyote Valley Dam
3	2	30-40	
2	1	40-50	
1	0	>50	

Note: These scores are applicable when ramping takes place during periods when flows are less than 500 cfs at the Ukiah gage.
* A score of 5 indicates lowest ramping rate and 1 indicates highest.

5.1.3 Annual and Periodic Dam Inspection and Maintenance

During dam inspection, maintenance activities, or changes in hydroelectric operations, releases from the dams are ramped-down or stopped altogether. These activities occur during summer or fall when salmonid fry are present, which are more susceptible to stranding than larger fish. The issues of concern for dam inspection and maintenance activities are bypass flows, and timing of inspection and maintenance activities.

5.1.3.1 Russian River

Flow interruption during dam inspections for 2 or more hours could pose a threat to young salmonids in the East Fork Russian River. Under the proposed project, a bypass flow of 25 cfs would be released from Coyote Valley Dam via the proposed bypass pump system. This would prevent dewatering, reduce the risk of stranding juveniles, and maintain rearing habitat in the East Fork and mainstem Russian River below the Forks, where stranding has been observed in the past.

At Coyote Valley Dam, fish rescue of juvenile steelhead was necessary on the East Fork and further downstream on the mainstem Russian River during inspection and maintenance activities in September 1998. However, in June 1999 when releases were near 0 cfs, no stranding of salmonids was documented. Habitat adequate to support fry and juvenile fish may have been maintained by dewatering the stilling basin, which provided up to 5 cfs for several hours following cessation of releases from the dam, and by flow accretion from seepage or groundwater contributions. Approximately 5 to 6 cfs has been measured at the weir after flows have ceased from Coyote Valley Dam (USACE 2003c). Very little to no mortality of federally listed species has been observed over the past 5 years during monitoring for inspection and maintenance activities when these activities have been scheduled for September (USACE 2003c). Inspections scheduled in the spring have resulted in a greater incidental take because of the smaller size and poorer swimming ability of younger fish (USACE 2003c).

Under the proposed project, bypass flows in the East Fork will be 25 cfs while maintenance and inspection activities are being conducted in the summer or fall.

5.1.3.2 Dry Creek

Because there is a bypass flow capability at Warm Springs Dam, dewatering is unlikely. Juvenile fish stranding has not been documented during recent inspection and maintenance activities.

Under the proposed program, the annual and periodic inspection and maintenance activities will be scheduled between July 15 and October 15. This would avoid periods when fry are present, and would occur after the smolts have migrated out.

5.1.4 HYDROELECTRIC FACILITIES AT WARM SPRINGS DAM

Hydroelectric facilities at Warm Springs Dam generate power from releases from Lake Sonoma. *Interim Report 7* (ENTRIX, Inc. 2000b) evaluated potential effects of hydroelectric operations on listed fish species. Under the Flow Proposal, the hydroelectric project will not be able to operate year-round. At flow releases of less than 75 cfs, the hydroelectric project is not operational. The effects on listed fish species when the hydroelectric operations are operating would be similar to those under baseline project operation. These effects that were evaluated in greater detail in *Interim Report 7* are summarized below.

Hydroelectric operations are incidental to water supply and flood control operations and therefore have no effect on streamflow or water temperature downstream of Warm Springs Dam. All maintenance activities occur within the Warm Springs Dam control structure shaft. During any unplanned events that require shutting down the generator, automatic controls shut down flows to the turbine and open a valve that bypasses flows around the turbine unit. Therefore, maintenance activities would not affect flows to Dry Creek and would not affect listed fish species.

The potential for the hydroelectric operation to result in dissolved gas supersaturation was evaluated as a potential effect on listed fish species. Gas supersaturation, especially nitrogen, below other hydroelectric facilities, has been known to cause gas bubble disease in juvenile and adult fish (Ebel and Raymond 1976). Dissolved gas supersaturation can be caused by the entrainment of air bubbles in the water under pressure.

Many causes of dissolved gas supersaturation in other river basins are not at work in the Russian River. There have been no reports of stress or mortality in fish directly below Warm Springs Dam. Dissolved gas levels have been measured at the inlet to the DCFH directly below the dam and data show gas levels at saturation (R. Gunter, CDFG, pers. comm. 2000a). If saturation levels of nitrogen were to increase, they would be expected to be restored to air saturation levels by turbulence in the discharge channels of the dam and in riffles and runs downstream of the facility. There are no indications that operations of the hydroelectric facilities at Warm Springs Dam bring gas supersaturation to a harmful level for listed fish species.

5.2 DIVERSION FACILITIES AND WATER SUPPLY AND TRANSMISSION SYSTEM

The operation and maintenance of the inflatable rubber dam at Mirabel and the Mirabel and Wohler diversion facilities could have effects on salmonids and their habitat, as follows.

Potential Direct Effects on Listed Species

- Passage of adult and juvenile salmonids past project facilities (dam and diversions), and potential migration delays.
- Entrainment into diversion ponds when stormflows overtop levees.
- Stranding potential from dam inflation and deflation.
- Injury to listed species from maintenance activities.

Potential to Alter Habitat

- Instream flow effects on habitat (addressed in Section 5.3).
- Alteration of habitat in Wohler Pool.
- Alteration of habitat from operation and maintenance activities.
- Water quality effects from accidental releases of chemical additives and facility maintenance substances.

Potential Indirect Effects

- Increase in predation risk from maintenance and operation activities.

In Section 5.2.1, fish passage in the following locations is evaluated: 1) past the inflatable dam, 2) past the Mirabel and Wohler screened diversions during both low-flow and high-flow seasons, and 3) through the impoundment (Wohler Pool) created by the inflatable dam. The potential to strand fish when the dam is inflated or deflated is evaluated in Section 5.2.2. In Section 5.2.3, Wohler Pool is evaluated for alteration of riverine habitat and its potential to create habitat for a warmwater fish community that could prey on salmonids. Finally, potential direct and indirect effects of operation and maintenance activities and water treatment facilities are evaluated.

5.2.1 FISH PASSAGE

The potential direct and indirect effects of the inflatable dam and the Mirabel and Wohler facilities on salmonid fish passage are considered. This section begins with an evaluation of adult salmonid migration through the fish ladders at the inflatable dam. This is followed by an evaluation of fish passage past the diversion facilities. Finally, juvenile fish passage through Wohler Pool is evaluated.

5.2.1.1 Fish Passage Past the Inflatable Dam

Fish Ladders

Adult upstream passage conditions past the inflatable dam are evaluated based on the effectiveness of the fish ladders installed at both sides of the dam. The evaluation is based on the design of the fish ladders compared to published criteria, results of a SCWA video monitoring study, and whether sufficient attraction flows are provided through the ladders. Additionally, the effects of a bypass pipeline at the dam are evaluated.

Two Denil-style fish ladders provide upstream passage for adult spawners when the inflatable dam is in operation. The inflatable dam is generally raised in April or May and deflated in November or December (Table 5-12). However, the dam could be raised and/or deflated earlier or later in the year, depending on weather and water demand.

The fish ladders generally operate at the beginning of the adult coho salmon upstream migration period and during the peak adult Chinook salmon migration period. The dam is not usually inflated during peak steelhead spawning migration because flows are generally too high (Table 5-11).

Table 5-11 Average Number of Days per Month that the Dam was Inflated, 1999 through 2002, and Adult Salmonid Upstream Migration Periods

Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Frequency	6	27	30	31	31	30	31	23	10	2	0	0
Adult Upstream Migration Period												
Coho												
Steelhead												
Chinook[1]												

[1] Under the proposed project, the sandbar would generally not be breached before mid-October, so Chinook salmon would not enter the river prematurely.

The design drawings of the Denil-style fish ladders show they are built within the guidelines of published criteria (see Appendix C). The fish ladders have approximate slopes of 1 foot of rise to 8 feet of run. Turning pools are located in each fishway to provide temporary, in-transit, and resting areas. Baffle sections provide less turbulent water on the bottom of each fishway. Sufficient water is provided to achieve fish attraction flows. The fishways are equipped with a trash rack to prevent clogging or damage due to debris.

A time-lapse (one image every 0.2 second) video monitoring system has been deployed at the upstream end of each fish ladder during the salmonid upstream migration periods when the dam has been inflated from 1999 to the present. Videotapes were reviewed on high quality VCRs with slow motion and freeze frame capabilities. Image quality was generally good to excellent, although turbidity occasionally made it difficult to collect data. When a fish was observed, tapes were reviewed frame by frame to determine the species and direction (upstream or downstream) of the fish. Data on adult migration through the ladder indicate salmonids can locate the fish ladders and pass successfully (Winzler and Kelly 1978; Chase et al. 2000, 2001, 2002). Even less powerful swimmers, such as Pacific lamprey, were documented to use the ladders successfully.

Snorkeling surveys were conducted below the inflatable dam every 2 to 3 weeks during the summer of 1999 to examine the possibility that adult salmon were holding below the dam before entering the ladders. If significant numbers of fish were found below the dam, there could be a delay in migration through the ladders. Although the video data are described as having "limited usefulness" because of limited visibility, no adult salmonids were observed (Chase et al. 2000), indicating no migration delay.

Table 5-12 shows the adult fish passage scores based on the risk the fish ladder design and operation poses to upstream migration. The fish ladder design is within the guidelines of published criteria. Video monitoring also confirms all adult species of salmonids appear to pass the inflatable dam without difficulty. The dam is generally not inflated during peak steelhead spawning migrations, but field data show that, when steelhead use the fish ladder, they pass successfully. Therefore, the adult upstream passage score for the inflatable dam is 5 for all three species.

Table 5-12 Adult Fish Passage Scores by Species at the Inflatable Dam – Fish Ladder Design and Operation

Category Score	Evaluation Categories	Current Operations Score*
5	Fish ladder passes adult salmon without delay.	Co, Ch, St
4	Fish ladder passes adult salmonids with acceptable delay.	
3	Fish ladder passes all target species after extended delay.	
2	Fish passage does not pass all target species of adult salmonids.	
1	Fish passage provided, but does not appear to pass any adult salmonids; or passage not provided.	

* Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Attraction Flows

Adult salmonid passage is also affected by attraction flows from the fish passage facility (fish ladder and bypass outfall). Insufficient attraction flows could make it difficult for adult fish to find the entrance to the fish ladder, thereby creating migration delays. If the amount of water provided for the fish ladder and bypass system is at least 10 percent of the total flow, attraction flow is sufficient to attract adults into the ladder entrance.

Interim Report 4 (ENTRIX Inc. 2001d) evaluated the amount of time that attraction flow would meet the 10 percent criterion under baseline flow and demand conditions. A

Russian River hydrologic simulation model was used to estimate streamflow at the dam during the months it was normally raised (late May through early November) over 35 water years (1960 to 1995). The amount of water diverted to the infiltration ponds or through the fish ladders and bypass facility was subtracted to estimate total streamflow at the dam. The simulations were used to predict how often flows passing through the fish passage facility would be less than 10 percent of total river flow.

Of the 35 water years evaluated, fish ladder flows were less than 10 percent of total river flow for approximately 11.5 days per year during dam inflation. Attraction flows below the desired 10 percent of streamflow generally occurred during high-flow storm events, when more water goes over the dam and therefore less than 10 percent of the flow is channeled through the fish passage facility. The daily data indicated that nearly all high-flow events in the river occurred when the dam was in operation late in the year (i.e., late October or early November), although a few events occurred early in the year as a result of late spring storms. The daily data showed that the duration of a high-water event that would affect attraction flows is normally short (i.e., 2 to 3 days).

In general, attraction flows under the proposed project would be sufficient to provide unrestricted passage for all three species of threatened salmonids. Storm events might still create temporary flows through the ladder of less than 10 percent of total flow. During the low-flow portion of the spawning season (late summer and early fall), all flow would go through the ladders or the bypass pipes. Therefore, implementation of the Flow Proposal would not increase the number of times attraction flows failed to meet the 10 percent criterion.

Bypass Pipeline

The bypass pipeline at the east side of the dam produces turbulent flow at the downstream entrance of the east-side fish ladder, which may impede passage. In 1999, flows through this bypass pipeline were decreased, resulting in decreased turbulence and enhanced functioning of the fish ladder. During the following 3 years, approximately 47 percent of the Chinook salmon counted during SCWA's video monitoring moved through the east-side fish ladder, which suggests the ladder functions effectively (S. Chase, SCWA, pers. comm. 2003a). If future monitoring suggests it is needed, SCWA would modify the east-side bypass pipeline to operate at its full 22-cfs capacity. Therefore, fish passage will not be delayed at the ladder on the eastern side of the dam. The west-side bypass line and fish ladder function properly.

Overall, adults of all three listed salmonid species pass through the fish ladder easily and without delay. Based on video monitoring in the ladders at Mirabel, it is evident that adults of all three listed species are able to locate the fish ladders and pass the inflatable dam (Chase et al. 2000, 2001, and 2002). Relatively large numbers of adult Chinook salmon and steelhead have been documented negotiating the ladders and large numbers of fish milling at the base of the dam have not been observed. Ladder design and operation conforms to published criteria for fish ladders. Sufficient attraction flows occur most of the time, and periods when the attraction flow criterion is not met are infrequent and of short duration.

5.2.1.2 Fish Passage Past Wohler Diversion

Many of the negative effects associated with water diversion facilities described in Section 3 are addressed in the proposed project. The proposed project minimizes the potential to impinge fry and juvenile salmonids by upgrading the fish screens at the diversion facilities to meet current NOAA Fisheries criteria.

During storm flows, levees at the infiltration ponds occasionally overtop, and listed fish species may be entrained. Under the proposed project, the infiltration ponds would be graded to minimize the risk of entrainment and a continual connection would be maintained from the Wohler ponds to the river during the high-flow season.

Fish Screens

The two Wohler ponds are operated independently and are filled by independent intake canals. New fish screens would be placed in permanent concrete intake structures at the terminus (river end) of each canal. The screens will consist of wedge-wire construction with 1.75-mm maximum-width slots and 50 percent open area. Each screen will be equipped with a mechanical cleaning mechanism. Because of the screen location at the ends of the canals, sweeping flows cannot be provided. However, the screened area will be large enough to minimize approach velocities at the screen face. Approach velocities will be regulated through manipulation of a slide gate.

Table 5-13 shows the criteria scores assigned to fish passage past the Wohler canal diversion. The screens will be designed to operate within NOAA Fisheries fish screen criteria for juveniles and fry. Therefore, the risk is low and the score is 5 for both juvenile and fry of all three species.

Table 5-13 Passage Scores for Fry and Juvenile Salmonids – Screen Design and Operation for the Wohler Canal Screens

Category Score	Evaluation Categories	Operations Score*
5	Fish screens meet NOAA Fisheries criteria and pass fish without injury or delay.	Co, St, Ch
4	Facility provided with fish screens, but the facility has a low risk of entrainment, impingement, or migration delay.	
3	Facility provided with fish screens, but the facility has a moderate risk of entrainment, impingement, or migration delay; effective rescue or escape is provided.	
2	Facility provided with fish screens, but the facility has a high risk of entrainment, impingement, or migration delay; ineffective rescue or escape is provided.	
1	Facility not provided with fish screens; no rescue or escape is provided.	

* Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Wohler Infiltration Ponds

The infiltration ponds occasionally flood during storm events. The ponds are isolated from the river by levees; when floods overtop the levees, salmonids (and potential predators) may be trapped in the ponds as water levels recede. This may subject salmonids to increased risk of injury, predation, and migration delays.

The potential effects on salmonids are evaluated based on the opportunity for entrainment, injury, or migration delays. The first component of the evaluation looks at the frequency of pond flooding within a year and the time of year the ponds are flooded (compared to salmonid migration periods). The second component addresses the risk of entrapment based on amount of water diverted into the ponds. SCWA fish rescue data are also examined to evaluate this risk. These components of the evaluation are then synthesized to evaluate the overall risk. Finally, recent modifications to the Wohler ponds and how they reduce this risk are discussed.

For the first component, pond flooding frequency and time of year, Table 5-14 provides estimates for the number of days the Wohler ponds would have overtopped over a 35-year period (1960 through 1995), based on results from computer simulations, and compares them to salmonid migration periods. The probability that the ponds would overtop in any day in a month is also listed. The model predicts that Wohler Pond 1 would have overtopped 533 days over the 35-year period and Wohler Pond 2 would have overtopped 625 days. Pond 1 would have flooded in 30 of the total 35 years and Pond 2 would have flooded in 31 years (Table 5-15). In general, overtopping is predicted to occur between November and April, which overlaps with the smolt outmigration period and adult upstream migration period of all three species. The highest probabilities of overtopping occur in January and February.

The probability that the ponds would overtop in any one day during a species' migration period was calculated by summing the number of days the ponds are predicted to overtop during the migration period and dividing by the total number of days in the migration period over a 35-year period. (This assumes overtopping events are independent and not cumulative.) For coho salmon downstream migration, that probability is 0.085 in Wohler Pond 1 and 0.102 in Wohler Pond 2. For the Chinook salmon migration period, the probabilities are lower, at 0.050 and 0.060 for Wohler Ponds 1 and 2, respectively. For steelhead, it is even lower, at 0.030 and 0.037, respectively. Therefore, there is a moderate risk of entrainment. The risk is highest for coho salmon because a greater proportion of the downstream migration period overlaps overtopping events.

The second component of the evaluation looks at the risk of entrapment based on the amount of water diverted into the ponds. Although the portion of the mainstem flows that enters the pond during flooding has not been measured, it is estimated at less than 5 percent, as the Wohler ponds are relatively small (1.4 acres). Because less than an estimated 5 percent of the flood streamflow enters the Wohler ponds, this component of the risk is low.

This analysis is consistent with data collected during fish rescue efforts in the infiltration ponds (Table 5-16) (SCWA 1998b, 1999c, 2000d). Fish rescue efforts at the Wohler ponds in 1998 and 1999 found only steelhead. Some Chinook salmon juveniles were rescued in 2000. Year-to-year variation in migration periods and storm events, or increases in coho salmon abundance, could result in the entrapment of coho salmon in future years.

A total of 79 juvenile hatchery steelhead (out of 850 fish of all species) were captured in 1998 during rescue efforts at the Wohler ponds. The steelhead captures in 1998 correlated with large releases of hatchery steelhead. Of these, 13 hatchery steelhead died during seining. In 1999, 29 hatchery steelhead and 32 naturally-spawned steelhead were rescued

Table 5-14 Total Number of Days per Month that Wohler Ponds 1 and 2 were Overtopped, 1960 through 1995 (Computer Simulation), and Probability of Overtopping During Months in Migration Periods

Wohler Pond 1												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Days per 35 Years[1]	169	135	100	30	0	0	0	0	0	0	25	74
Probability per Day	0.156	0.138	0.092	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.068
Wohler Pond 2												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Days per 35 Years	188	161	120	36	0	0	0	0	0	2	28	90
Probability per Day	0.173	0.164	0.111	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.083
Juvenile Emigration Periods												
Coho												
Steelhead												
Chinook												
Adult Upstream Migration Periods												
Coho												
Steelhead												
Chinook[2]												

[1] The total days the ponds could potentially overtop is 35 years x 120 days/year = 4,200 days.

[2] Under the proposed project, the sandbar would generally not be breached before mid-October, so Chinook salmon would not enter the river prematurely.

Table 5-15 Number of Days by Water Year that the Wohler Ponds Would Have Overtopped, 1960 through 1995 (Computer Simulation)

Wohler Pond 1		Wohler Pond 2	
Water Year	Number of Days Exceeded[1]	Water Year	Number of Days Exceeded[1]
WY 1960	10	WY 1960	11
WY 1961	7	WY 1961	11
WY 1962	15	WY 1962	17
WY 1963	20	WY 1963	28
WY 1964	3	WY 1964	4
WY 1965	23	WY 1965	25
WY 1966	10	WY 1966	14
WY 1967	21	WY 1967	22
WY 1968	7	WY 1968	8
WY 1969	35	WY 1969	43
WY 1970	32	WY 1970	34
WY 1971	16	WY 1971	21
WY 1972	0	WY 1972	0
WY 1973	30	WY 1973	32
WY 1974	35	WY 1974	38
WY 1975	17	WY 1975	21
WY 1976	0	WY 1976	0
WY 1977	0	WY 1977	0
WY 1978	30	WY 1978	31
WY 1979	7	WY 1979	9
WY 1980	25	WY 1980	28
WY 1981	6	WY 1981	6
WY 1982	36	WY 1982	42
WY 1983	63	WY 1983	71
WY 1984	20	WY 1984	21
WY 1985	3	WY 1985	4
WY 1986	28	WY 1986	30
WY 1987	2	WY 1987	3
WY 1988	3	WY 1988	6
WY 1989	1	WY 1989	4
WY 1990	0	WY 1990	0
WY 1991	2	WY 1991	5
WY 1992	0	WY 1992	2
WY 1993	7	WY 1993	10
WY 1994	0	WY 1994	0
WY 1995	19	WY 1995	24

[1] Number of days flows were high enough that the pond levees were predicted to overtop.

Table 5-16 Summary of Salmonids Captured in the Mirabel and Wohler Infiltration Ponds during Fish Rescue Efforts

	Chinook			Steelhead (Wild)			Steelhead (Hatchery)		
	1998	**1999**	**2000**	**1998**	**1999**	**2000**	**1998**	**1999**	**2000**
Pond Number[2]									
Mirabel Pond 1	6			0			0		
Mirabel Pond 2	2			0			0		
Mirabel Pond 3	1/1[1]			0			0		
Mirabel Pond 4	1/1[1]			0			0		
Sedimentation Pond	0			0			0		
Wohler Pond 1	0	0	1	0	17	2	50	29	9
Wohler Pond 2	0	0	8	0	15	66	16/13[1]	0	0
Total	**12**	**0**	**9**	**0**	**32**	**68**	**79**	**29**	**9**

[1] Two numbers indicate number rescued/number of mortalities.
[2] In 1998, there was one rescue event in the Mirabel ponds, but none in 1999 or 2000. In 1998 and 1999, there were two rescue events in the Wohler Ponds each year; in 2000, there were two in Wohler Pond 1 and four in Wohler Pond 2.

from the Wohler ponds, out of a total of 539 fish. One adult steelhead mortality was found in the outlet culvert at Wohler Pond 2 in March 1999, and one unmarked (not hatchery marked) adult steelhead was rescued in March 1999. In 2000, 84 juvenile salmonids were returned to the river and 2 died.

Integrating these components of the evaluation, less than 5 percent of streamflow during flood events enters the Wohler ponds, and the ponds can overtop during a small portion of the migration periods of all three species. This could pose a small risk to downstream migration of juveniles. Fish rescue data from past years demonstrate that salmonids are occasionally entrained.

However, modifications at the Wohler ponds are likely to reduce this risk to a very low level. The Wohler ponds would be regraded to direct fish towards the inlet/outlet pipe, significantly reducing the potential for entrapment and minimizing the need for fish rescue operations. (The fish screens would not be in place during the high-flow events.) Because an effective, continual connection would be maintained between the pond and the river, fish would be able to return to the river at will, and the overall risk of injury or mortality would be reduced to a very low level. By providing an area of refuge from high-flow events in the river, this connection may benefit some salmonids. Fish rescue operations would be conducted, if needed, when water levels recede.

5.2.1.3 Downstream Fish Passage Past Mirabel Diversion

As with the Wohler diversion, the effects of the Mirabel diversion on salmonid migration are assessed by evaluating the fish screen design and operation and the opportunity for fish to be impinged or injured at the facility fish screens. Proposed modifications to the fish screens are evaluated.

The risk of entrainment is also evaluated for occurrences of pond levees overtopping during the high-flow season. Proposed actions designed to minimize this risk are evaluated.

Fish Screens

Under baseline conditions, the fish screens at the Mirabel diversion facility meet most NOAA Fisheries criteria for juveniles, but not for fry. Table 5-17 summarizes the design criteria for the proposed project changes in screen design and the NOAA Fisheries criteria for fry and juveniles. Several NOAA Fisheries criteria for fish screens are more stringent for fry than for juveniles. For example, they specify that approach velocities cannot exceed 0.33 fps, that a perforated plate-screen opening cannot exceed 3/32 inches in diameter, and that a minimum of 27 percent of open area on the screen is required for fry.

The proposed design meets, or exceeds, the NOAA Fisheries criteria for both fry and juveniles (Table 5-17). The screen area is approximately 25 percent greater than the size required to meet the 0.33-fps approach velocity criterion. The additional area is provided to allow for variation in operating parameters.

Table 5-17 Critical Operating Parameters for Proposed Mirabel Fish Screens

Parameter	Mirabel Fish Screens	NOAA Fisheries Juvenile Criteria	NOAA Fisheries Fry Criteria
Net equivalent submerged screen area	450 square feet		
Screen open area	50%	40% open area	27% open area
Approach velocity	≤ 0.33 fps	≤ 0.8 fps	≤ 0.33 fps
Sweeping velocity	Upstream: 2.0 fps Downstream: 1.33 fps	Greater than approach velocity (sufficient to sweep debris away from screen face)	Greater than approach velocity (sufficient to sweep debris away from screen face)
Screen opening size	1.75 mm slot width	≤ 8/32 inches	≤ 1.75 mm slot width

With the current design, smolts tend not to use the fish ladder for downstream migration. Under the proposed project, the upstream portion of the fish ladder would be redesigned. Integration of the intake structure with the top of the fish ladder would improve passage conditions for fry and juvenile salmonids past the diversion facility.

Other critical operating parameters meet the NOAA Fisheries criteria for juvenile salmonids. A traveling vertical brush would keep the screens free of silt and other debris, and a trash rack would be installed on the ends of the intake structure. Due to location and a consistent pool elevation, hydrologic conditions at the screens have little variability so diversion operations should remain relatively consistent. Because the Mirabel pumped diversion screen design and operation would be consistent with NOAA Fisheries criteria, juveniles and fry of the three salmonid species would safely migrate down the river past the screened diversion. Therefore, the score for screen design and diversion passage is 5 (Table 5-18).

Table 5-18 Passage Scores for Fry and Juvenile Salmonids – Screen Design and Operation for the Mirabel Pump Diversion

Category Score	Evaluation Categories	Operations Score
5	Fish screens meet NOAA Fisheries criteria and pass fish without injury or delay.	Co, St, Ch
4	Facility provided with fish screens, but the facility has a low risk of entrainment, impingement, or migration delay.	
3	Facility provided with fish screens, but the facility has a moderate risk of entrainment, impingement, or migration delay; effective rescue or escape is provided.	
2	Facility provided with fish screens, but the facility has a high risk of entrainment, impingement, or migration delay; ineffective rescue or escape is provided.	
1	Facility not provided with fish screens; no rescue or escape is provided.	

* Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Mirabel Infiltration Ponds

The infiltration ponds at Mirabel are less likely to flood during storm events than the ponds at Wohler. Salmonids may be subjected to a risk of entrainment, injury, predation, and migration delays during high-flow events.

Table 5-19 provides estimates for the number of days the Mirabel ponds would have overtopped over a 35-year period (1960 through 1995), based on results from computer simulations, and compares them to salmonid migration periods. The probability that the ponds would overtop in any day in a month is also listed. The model predicts that the Mirabel ponds would have overtopped 32 days over the 35-year period and at least once in 15 of the 35 years, and flooded only 14 days during this time period (the ponds could overtop for more than one day during a single flood event) (Table 5-20).

The ponds are predicted to overtop only during December through March. Based on the probability of overtopping in any one day in the month, the risk would be highest in January (Table 5-19).

The probability that the ponds would overtop in any one day during a species migration period was calculated by summing the number of days the ponds are predicted to overtop during the migration period and dividing by the total number of days in the migration period over a 35-year period. For coho salmon downstream migration, that probability is 4.1×10^{-6} and for Chinook salmon it is 2.5×10^{-6}. For steelhead, it is even lower, at 8.6×10^{-7}. Fry-rearing periods also have some overlap. Thus, during the migration periods of all three species, the ponds overtop very infrequently. It should be noted that salmonid migration can be cued by stormflow events, thereby concentrating the numbers of salmonids that would pass during storm events and increasing the probability of

Table 5-19 Total Number of Days per Month that Mirabel Infiltration Ponds were Overtopped from 1960 through 1995 (Computer Simulation), and Probability of Overtopping During Months in Migration Periods

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Days per 35 Years[1]	14	9	4	0	0	0	0	0	0	0	0	5
Probability per Day	0.129	0.009	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
Juvenile Emigration Periods												
Coho												
Steelhead												
Chinook												
Adult Upstream Migration Periods												
Coho												
Steelhead												
Chinook												

[1] The total days the ponds could overtop is 35 years x 365 days/year = 12,775 days

entrapment. However, given the extremely low probability of overtopping during the migration period, this increase in entrapment probability is insignificant.

The risk to migrating salmonids at the Mirabel infiltration ponds also depends on the percent of river flow entering ponds during flood flows. Although the portion of surface water that enters the Mirabel ponds during flooding has not been measured, it is estimated at less than 5 percent of the flood flow. Descriptions of flooding in fish rescue reports suggest that the ponds are full within approximately 5 hours (SCWA 1998b, 1999c). During those 5 hours, a small portion of the mainstem flood flows enter the ponds. Because less than 5 percent of flood flow is ever diverted into the ponds, the risk to salmonids from flooding is low.

Another reason for the low overall risk to salmonids is that overtopping of the Mirabel ponds is rare (32 days over a modeled 35-year period). Of the three species, the risk to steelhead is lowest because the ponds overtop only during a very small portion of the steelhead juvenile migration period. Coho and Chinook salmon juveniles, more likely to be migrating through the area when the ponds overtop, are at a slightly greater risk of entrapment or migration delays. While individual fish may be affected, the overall risk to the populations is low.

This analysis is consistent with data collected during fish rescue operations (Table 5-16) (SCWA 1998b, 1999c, 2000c). Rescue efforts were not necessary in 1999 or 2000 because the Mirabel infiltration ponds did not flood. In 1998, rescue efforts at Mirabel ponds captured 12 juvenile Chinook salmon out of 3,595 fish of all species. Of these, 10 Chinook salmon were released and 2 died. One Chinook salmon mortality was probably associated with high water temperatures, and one with the rescue effort. Neither coho salmon nor naturally-spawned steelhead juveniles was captured.

Table 5-20 Number of Days by Water Year that Mirabel Infiltration Ponds Would Have Overtopped, 1960 through 1995 (Computer Simulation)

Water Year	Number of Days Exceeded[1]
WY 1960	0
WY 1961	0
WY 1962	0
WY 1963	1
WY 1964	0
WY 1965	3
WY 1966	1
WY 1967	0
WY 1968	0
WY 1969	1
WY 1970	3
WY 1971	1
WY 1972	0
WY 1973	1
WY 1974	2
WY 1975	1
WY 1976	0
WY 1977	0
WY 1978	2
WY 1979	0
WY 1980	1
WY 1981	1
WY 1982	3
WY 1983	4
WY 1984	0
WY 1985	0
WY 1986	6
WY 1987	0
WY 1988	0
WY 1989	0
WY 1990	0
WY 1991	0
WY 1992	0
WY 1993	0
WY 1994	0
WY 1995	1

[1] Number of days flows were high enough that the pond levees were predicted to overtop.

Year-to-year variation in migration periods and storm events could result in the capture of naturally-spawned steelhead or coho salmon in future years. While fry have not been captured in the ponds, it is likely that small fish would not survive for the 2-week period because cover is not available and predatory fish are present. Steelhead YOY were also generally not captured, although an unusually high number of small fish (approximately 200 individuals) were captured in Wohler Pond in 1998 after the hatchery had released approximately 150,000 surplus production juveniles (this practice has been discontinued). However, SCWA screwtrap data indicate that very few steelhead YOY are in the Wohler area prior to April (although the flood of April/May 2003 may have affected steelhead YOY that year).

Anglers report fish (species unknown) jumping in the ponds (B. Coey, CDFG, pers. comm. 2000b). Fish rescues in recent years have recovered less than a dozen adult steelhead, and most of these were at the Mirabel ponds after significant flooding in 1997 (S. White, SCWA, pers. comm. 2000). Adult steelhead were not captured in the Wohler or Mirabel ponds in 1998 or 1999. Piscivorous fish species, including Sacramento pikeminnow and bass, were also captured during fish rescues.

In 1999, structures were installed in the Mirabel ponds to reduce stress on fish, reduce residence time of fish trapped in the ponds, and facilitate rescue operations. Although fish rescues do not reduce the probability of entrapment, returning trapped fish to the river reduces mortality rates. “V” ditches and sumps installed in the ponds provide a refuge from predators and high water temperatures. They also increase the efficiency of rescue operations by concentrating fish. Although some fish may be lost to injury or stress during rescue operations, improved fish rescue operations (conducted within 2 weeks) help minimize risks to listed species. However, juvenile fish are at risk of predation during that time.

5.2.1.4 Wohler Pool

When inflated, the dam at Mirabel impounds water for approximately 3.2 miles upstream. This impoundment (Wohler Pool) decreases current velocity, which could delay emigrating smolts. Recent SCWA and NOAA Fisheries studies have documented migration delays of smolts at the dam. Data suggest that steelhead smolt outmigration is delayed when the dam is inflated (Manning et al. 2001, Manning 2003), while Chinook salmon migration is not (Chase et al. 2002).

From 2000 to 2002, radiotelemetry was used to evaluate steelhead migratory behavior, passage, and survival, using hatchery steelhead from DCFH. Results of the study are presented in Section 3. The study evaluated fish passage through the reservoir and forebay behind the dam. In 2001 and 2002, a riverine control reach was added to the study after the dam was inflated. In 2001, the dam was operated fully inflated, but in 2002, the height of the dam was decreased to increase spill depth and velocity (notch configuration) during part of the study. A key finding from the 2001 and 2002 data is that smolts traveled through the river and reservoir at approximately the same rate, despite decreased velocity in the reservoir, even over a range of river flows. Unlike travel rates, there were statistically significant differences in median residence times. River residence times did not differ between 2001 and 2002, but reservoir and forebay times dropped from 21.50 and 6.25 hours to 10.47 and 0.81 hours, respectively. There was a statistically significant difference in river and reservoir residence times in 2001, but not in 2002. Forebay time was significantly lower in 2002 than in 2001. Findings suggest that delays in emigration under baseline operations were limited to the forebay and were due to the inability of the smolts to pass the dam rather than to a decrease in current velocities within the impounded reach. This analysis evaluates a proposed operation at the dam that is designed to facilitate passage past the dam.

Notching the Dam

Under the proposed project, a depression would be created in the crest of the inflatable dam during outmigration periods (through June 15). This would provide concentrated flow at a point along the dam and a localized point of discovery for fish moving over the dam.

Observations at dams in the Columbia River system have revealed that juvenile salmonids are attracted to surface-oriented spillways (Christensen and Wielick 1995). Orifices were placed in the dam walls near the surface of the dam forebay to provide a surface collector system. When applied properly, these systems have generated more than 90 percent in fish guidance efficiencies. A 3-year study on Wells Dam documented a fish guidance efficiency of 90 percent, and fish guidance efficiencies as high as 97 percent have been recorded at other dams (Christensen and Wielick 1995).

In spring 2002, SCWA and NOAA Fisheries conducted a series of experiments that manipulated the bladder of the inflatable dam to produce an irregular crest. The team was able to create a stable notch of approximately 1.0- to 1.5-feet in the dam crest at a consistent location. Smolts subsequently moved over the dam crest through the notch. Although a small sample size (number of passing fish) did not yield statistically significant differences between notched and full-dam configurations, observations suggest that the notch is effective at reducing forebay residence time (Manning 2003).

The preliminary experiments at the dam indicate that creation of the notch in the dam crest would effectively pass outmigrating smolts by providing a detectable current and flow pathway over the dam.

The modifications to the Mirabel diversion facility include a new, flat plate-screen system and integration of the intake structure with the existing fish ladder. Integration of the intake structure and fish ladder will allow more effective use of river flows to create sweeping velocities and enhance downstream passage of fish.

5.2.2 Effects from Dam Inflation and Deflation

Inflation and deflation of the dam decrease the river stage above and below the dam, creating the potential for fish stranding upstream and downstream, respectively. The rate of change in the river stage in these areas depends on the rate the dam is raised or lowered. Rapid changes in the river stage can dewater habitat occupied by juvenile and adult salmonids. Stranding occurs when fish are separated from flowing water, and can occur in riffles, gravel bars, side channels, and backwater pools. Mortality may result if fish become desiccated or suffocate when trapped in isolated pools. Trapped fish may be at a higher risk from predation. Juvenile salmonids are more vulnerable to stranding than adults. Vulnerability to stranding drops significantly when young steelhead reach 40 mm and young Chinook reach 50 mm to 60 mm (Beck Assoc. 1989, cited in Hunter 1992).

Inflation of the dam during low-flow conditions would most likely occur in early spring when juveniles or fry of all three species may be present. The dam is generally deflated in the late fall or early winter in response to an impending storm event, and remains deflated throughout the winter. Emergency deflation may occur during the spring.

Evaluation of the effects on juvenile salmonids is based on three components: the rate of stage-change during dam inflation/deflation; habitat features in the affected area; and the frequency of dam inflation/deflation. These components are then synthesized to evaluate the overall risk. The criteria for stage-change rates are modified from the Washington Department of Fisheries guidelines (Hunter 1992). It should be noted that the Hunter (1992) guidelines are considered to represent a conservative ramping standard for the Russian River. Hunter developed his guidelines based on streams located in the Northwest, where the hydrologic regime is dominated by snowmelt processes. Those streams usually have relatively gradual changes in flow conditions. In contrast, the Russian River drainage has very "flashy" flow-runoff conditions and can experience relatively large stage changes over a short period in response to natural hydrologic conditions.

5.2.2.1 Dam Deflation

As the dam is deflated, water levels decline upstream of the dam. Flow recessions in the impounded reach (approximately 3.2 stream miles) could result in salmonid stranding or displacement. Although salmonid stranding has not been documented, SCWA staff noted stranding of warmwater fish species (suckers, tuleperch, and hardhead) in 2003 (S. Chase, SCWA, pers. com. 2003a).

Generally, the dam is lowered each fall or early winter as river flow increases. Adults, if present, are not likely to be at risk during their spawning runs because they are less susceptible to stranding than juveniles. The dam can also be lowered in early spring in response to late storms. Juvenile coho salmon, steelhead, and Chinook salmon migration periods occur during the early spring.

Rate of Stage Change

The rate of stage change in the river when the dam is lowered is estimated with a simple calculation. The dam is 11 feet high when raised and normally takes 24 hours to lower. The stage change is approximately 0.46-foot per hour (11 feet divided by 24 hours = 0.46-foot per hour). The scores for this rate of stage change are 3 for juveniles (Table 5-21) and 2 for fry (Table 5-22).

Table 5-21 Stage-Change Evaluation Scores for Dam Inflation and Deflation by Species for Juvenile and Adult Salmon

Category Score	Evaluation Categories	Current Operations Score*
5	Meet 0.16 ft/hr maximum stage change.	
4	Meet 0.32 ft/hr maximum stage change.	
3	Meet 0.48 ft/hr maximum stage change.	Co, St, Ch (deflation)
2	Meet 1.4 ft/hr maximum stage change.	Co, St, Ch (inflation)
1	Greater than 1.4 ft/hr maximum stage change.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Table 5-22 Stage-Change Evaluation Scores for Dam Inflation and Deflation by Species for Fry

Category Score	Evaluation Categories	Current Operations Score*
5	Meet 0.08 ft/hr maximum stage change.	
4	Meet 0.16 ft/hr maximum stage change.	
3	Meet 0.32 ft/hr maximum stage change.	
2	Meet 0.48 ft/hr maximum stage change.	Co, St, Ch (deflation)
1	Greater than 0.48 ft/hr maximum stage change.	Co, St, Ch (inflation)

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Habitat Features

Habitat features in the upstream channel also affect the potential for stranding salmonids. A low-gradient river with many side channels, potholes, low-gradient gravel bars, and an abundance of large substrates and aquatic vegetation has a greater incidence of stranding than a single-channel river with steep banks (Hunter 1992).

Habitat surveys upstream and downstream of the dam were conducted by SCWA in 1998 and 1999 (SCWA 2000b). Under free-flowing conditions, aquatic habitat upstream of the dam is dominated by run-habitat, while the downstream reach is a low-gradient channel dominated by relatively long, wide pools. When the dam is not inflated, upstream habitat consists of swiftly flowing reaches with little surface agitation and no major flow obstructions. Once the dam is inflated, upstream habitat is converted to primarily pool habitat. Typical substrate in this reach consists of sand and gravel, with fine sediments in interstitial spaces.

Bradford et al. (1995, cited in Hunter 1992) found that stranding of juvenile coho salmon was reduced when the cross-section of channel slope of the bar exceeded 6 percent. A steeper slope results in a less shallow area along the margins of the stream where fish are vulnerable to stranding. The slopes of the Russian River margins are relatively low-gradient, but are sloped to the main channel. However, the upstream habitat is primarily run or pool habitat, with relatively few structural features that would create low areas outside the main channel, such as side channels and potholes.

Because few habitat features upstream of the dam would induce stranding during the flow recessions that occur when the dam is deflated, there is little risk of stranding. Thus, the score is 4 for fry, juvenile, and adult salmonids of all three species (Table 5-23).

Table 5-23 Flow-Fluctuation Evaluation Scores Related to Opportunity for Stranding or Displacement for Fry, Juvenile, and Adult Salmon – Habitat-Related

Category Score	Evaluation Categories	Current Operations Score*
5	Habitat features unlikely to induce stranding.	
4	Few habitat features present to induce stranding.	Co, St, Ch (deflation)
3	Some habitat features that induce stranding, but area affected is small (<30%).	Co, St, Ch (inflation)
2	Many habitat features that induce stranding, but area affected is small (<30%).	
1	Some habitat features that induce stranding, area affected is large (>30%).	
0	Many habitat features that induce stranding, area affected is large (>30%).	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Frequency of Deflation

The opportunity for stranding is directly related to the frequency of fluctuations in flow or stage. The dam was deflated on average approximately 1.5 times per year between 1978 and 1998, but it could be lowered as many as three times in a year (see Table 3-3, Inflatable Dam Operation History). Because dam deflation generally occurs in response to rising river flow, low-flow deflation events are rare (and limited to emergency conditions).

Flow fluctuations due to inflation/deflation occur on average only 3 times per year. Based on this analysis, the score for the effects of dam inflation/deflation on juveniles of all three species is 4 (Table 5-24).

Table 5-24 Flow-Fluctuation Evaluation Scores Related to Opportunity for Stranding or Displacement for Fry, Juvenile, and Adult Salmon – Frequency of Occurrence

Category Score	Evaluation Categories	Current Operations Score*
5	Less than 2 fluctuations per year in habitat.	
4	Between 3 and 9 fluctuations per year in habitat.	Co, St, Ch
3	Between 10 and 29 fluctuations per year in habitat.	
2	Between 30 and 100 fluctuations per year in habitat.	
1	More than 100 fluctuations per year in habitat.	
0	Daily fluctuations in habitat.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

The overall risk of frequent flow fluctuations to coho salmon, steelhead, and Chinook salmon is low. Dam deflation rates may pose a moderate risk of stranding for juvenile salmonids. The risk for fry in the spring is higher. However, there are few upstream habitat features likely to promote stranding. More importantly, springtime dam deflation, when juvenile salmonids and fry are present, occurs infrequently. When the dam is deflated in the late fall/early winter, Chinook salmon are incubating in the gravel, while small steelhead and coho salmon are primarily in tributary streams. Therefore, although some fish may be stranded, the overall risk to listed species populations is low.

5.2.2.2 Dam Inflation

Rate of Stage Change

Larger stage changes may occur when the dam is inflated than when it is deflated because river flow is likely to be lower.

When the dam is inflated, it begins to impound water and flow is reduced downstream. Water spills over the dam until it is about two-thirds inflated, then most of the flow passes through the ladders and associated bypass pipelines. Inflating the dam will change the water level downstream until stable flows through the ladders and associated bypass pipelines are established.

Under the proposed project, the two fish ladders would operate at a maximum of 20 cfs and provide a maximum juvenile bypass pipeline rate of 20 cfs. As the head behind the dam increases, flow through the ladder and bypass pipes increases until it reaches operating flows.

Water surface elevations downstream of the dam were monitored during a dam inflation event on May 22, 2003. Dam inflation began at 9:00 a.m., and monitoring began at 10:30 a.m. At 12:10 p.m., flows increased, which appeared to reduce the rate of stage-change. Calculated stage-changes ranged from 0.30 ft/hr to 0.62 ft/hr (Table 5-25). The largest stage-changes occurred near the beginning of the dam inflation. By the end of the process, stage-changes had stabilized to approximately 0.40 to 0.48 ft/hr. Stage-changes were calculated from the data as follows.

Table 5-25 Stage Changes Downstream of the Inflatable Dam during Inflation on May 22, 2003

Time	WSE (ft)	Stage Change (ft/hr)
10:30	13.30	
11:00	13.02	0.56
11:30	12.71	0.62
12:10	12.38	0.49
12:30	12.28	0.30
13:00	11.98	0.60
14:00	11.58	0.40
15:00	11.12	0.46
16:00	10.70	0.42
17:00	10.22	0.48

SCWA 2003c.

Stage-changes documented during the first half of the period of the inflation equate to a score of 2 for juveniles and 1 for fry. For this component of the evaluation, the risk to small fish downstream of the dam is high.

Habitat Features

The river downstream of the dam has long pool sections, and some shallow riffles. When the dam is inflated, a double thalweg in the run directly downstream extends for approximately 250 feet. Farther downstream, a long pool extends approximately 0.25 miles. The river constricts downstream of this pool, then becomes a shallow riffle/run before forming another long pool.

Because there are riffles downstream of the dam, the risk for stranding is slightly higher than for the upstream reach. Therefore, the score for effects of downstream habitat features on stranding during dam inflation is 3 (Table 5-23).

Overall, the risk of stranding is higher during spring inflation (and rare emergency deflation) than during dam deflation because flows are likely to be lower and fry are likely to be present. Migrating smolts are also likely to be present. Small Chinook salmon that are migrating in the early spring may be at risk, but by mid-spring, when the dam is more likely to be operational, average Chinook salmon lengths are generally longer than 60 mm FL (Chase et al. 2003), which reduces the risk. Chinook salmon averaged approximately 35 to 40 mm FL during the first few weeks of their life in 2002, then quickly grew to approximately 80 mm by mid-April. Steelhead YOY may also be at risk. Steelhead YOY became abundant in mid-April 2002, at an average of approximately 40 mm FL, but the average size increased from 44 mm to 84 mm between April and June

2000. Coho salmon fry are likely to use tributary habitat rather than mainstem habitat, and therefore have a very low risk level. Steelhead and coho salmon downstream migrants are present in the mainstem during the spring, but are much larger and therefore have a lower risk level than YOY.

Large stage changes may result in flow recessions that strand juvenile and fry on riffles downstream of the dam. However, riffles downstream of the dam tend to be short and shallow, have sand/gravel substrate, and do not provide prime habitat, which reduces the risk. Furthermore, the dam is inflated infrequently. Therefore, individual fish may be stranded, but the effect to the population would not be high.

5.2.3 Habitat Alterations in Wohler Pool

This section evaluates alterations to salmonid habitat by the impoundment of Wohler Pool related to physical habitat, temperature, DO, predation, and the potential for bank erosion.

Impoundment of water behind the inflatable dam increases upstream pool habitat. This habitat alteration could affect rearing conditions and smolt emigration for salmonids by changing the pool/run/riffle ratio, channel geomorphology, water temperatures, and species (predator) composition. In this section, data from SCWA's 5-year monitoring program are summarized and used to evaluate potential effects on salmonids. Changes in this habitat that are likely to occur under the Flow Proposal are also considered.

Under free-flowing conditions, the stream reach in the Wohler Pool area may provide rearing habitat for steelhead and Chinook salmon in the spring. This time of year, the water temperature in this part of the mainstem is optimal for salmonid growth. Chinook salmon migrate through the area by the end of June, generally before water temperatures become high (Chase et al. 2003). Coho salmon rear in the Russian River tributaries rather than the mainstem, and coho salmon YOY have not been found near the Wohler Pool (Chase et al. 2003). High summer water temperatures may limit rearing habitat in the Lower Russian River in the summer (see Section 2), even under D1610 minimum flows.

When the dam is inflated, the amount of pool habitat is increased while riffle/run habitat is decreased. This likely results in a decrease in the amount of steelhead and Chinook salmon rearing habitat. When salmonids rear in warm water, their metabolism is high and they require more food for maintenance and growth. Because transport of sufficient quantities of food (through fast water such as runs and riffles) is important for rearing, a change from run to pool habitat in the impounded reach above the dam may affect salmonid growth. Sufficient food transport is most needed during the early summer when water temperatures become warm.

Riparian vegetation could be weakened if the edges of the river become inundated, leading to bank erosion when flows increase. However, the width of the upstream wetted channel is not significantly different when water is impounded by the dam compared to the rainy season when the river flows freely. Therefore, the proposed project is not likely to lead to increased bank erosion.

5.2.3.1 Steelhead Rearing in Wohler Pool

Steelhead YOY were captured downstream of the dam in the spring of all years sampled with the rotary screw trap (Chase et al. 2002, 2003) (see Table 2-10). A few steelhead YOY were also captured in the Wohler Pool during electrofishing surveys in August 2000 through 2003. These fish were generally larger than similar-age steelhead captured in Mark West and Santa Rosa creeks during fall surveys (Chase et al. 2003), suggesting that growth rate in the river may be higher. Eight wild and one hatchery steelhead were captured during the August 2001 sampling event. The captured wild steelhead ranged in length from 105 mm to 225 mm, and consisted of all year classes (Ages 0+ to 4+). The large number of steelhead YOY documented in the 2002 rotary screw trap data suggest that some steelhead may be rearing in this portion of the mainstem under baseline conditions.

The impoundment converts steelhead habitat in the mainstem to pools, which may negatively affect summer growth. However, juvenile steelhead are not likely to be abundant in Wohler Pool in the summer. Not only are summer water temperatures too high to provide suitable summer rearing habitat in this portion of the mainstem, but a relatively small portion of the river is affected. Therefore, the risk to the population is low.

5.2.3.2 SCWA Wohler Pool Habitat Data Collection

SCWA has collected habitat data in four reaches of the Wohler Pool area since 1999, as part of a 5-year study (Chase et al. 2000, 2001, 2002, 2003).

- Reach 1, located downstream (approximately 2.5 km [1.5 miles]) of the inflatable dam adjacent to Steelhead Beach Regional Park.
- Reach 2, located in lower Wohler Pool.
- Reach 3, located in upper Wohler Pool.
- Reach 4, located upstream of Wohler Pool in a relatively shallow glide (maximum depth 1.5 to 2.0 feet). Minimally affected by dam operations.

Average widths and depths were similar between the four reaches, except for a small hole (5.0-m deep) at the upstream end of Reach 3. Overall percentages of cover (e.g., overhanging vegetation and woody debris) were similar in the three reaches upstream of the dam.

All four reaches provide suitable habitat for piscivorous fish species (i.e., bass and Sacramento pikeminnow). The lower half of Wohler Pool provides the best habitat for smallmouth and largemouth bass because it has the deepest water, the lowest current velocities, and the most abundant cover. During the winter/early spring, when streamflows are decreasing (prior to dam inflation), low-velocity, deep-water habitat is still available in Reaches 1, 3, and 4. Reach 1 is a main-channel pool under summer base flows, and as high winter flow subsides, habitat returns to this condition. Therefore, low-flow velocity refuge remains throughout the winter-to-summer transition period. Reach 4 is also primarily pool habitat.

Without the dam, Reach 3 would be classified primarily as a run/glide habitat. The thalweg runs against one of the banks, so that as streamflow decreases from winter to summer flows, moderate depths and cover (mainly overhanging vegetation and large woody debris) provide velocity refuge for fish. Habitat in the lower half of Reach 2 consists of a series of relatively shallow riffles and glides with moderately high-velocity currents, and the thalweg runs through the middle of the channel, away from overhanging vegetation. Refuge from the relatively high-velocity currents is lacking during the winter-to-summer transition period in the lower portion of Wohler Pool.

5.2.3.3 Temperature in Wohler Pool

During SCWA's 5-year study at Wohler and Mirabel facilities, water quality (water temperature, DO, and conductivity) has been monitored under D1610 flows at stations located approximately 6.5 km upstream to 2.3 km downstream of the dam (Chase et al. 2000, 2001, 2002, 2003). These data are used to characterize project effects.

When the dam is inflated, it increases the residence time and surface area of water in the pool, resulting in greater solar heating. Higher temperatures could potentially affect salmonid rearing and migration. Since 1999, a series of water-temperature monitoring stations upstream, within, and downstream of Wohler Pool has been used to record water temperatures. Water temperature and DO profiles have also been collected periodically at the reach stations.

The water temperature monitoring study objectives are threefold and are listed in order of highest to lowest priority:

1. Evaluate whether water impoundment behind the dam increases the rate of warming relative to free-flowing conditions.

2. Provide a general description of the spring-through-fall thermal regime within the study area and compare it to the temperature requirements of salmonids and predatory fish species.

3. Assess the potential for thermal stratification in Wohler Pool.

The Flow Proposal would alter summer flows in this portion of the mainstem. Therefore, the thermal regime is likely to change. However, the data collected under D1610 flows can be used to generally characterize the effects that impoundment may have on salmonid species.

Wohler Pool is shallow (approximately 2 m to 3 m) and did not show thermal stratification (Chase et al. 2000, 2001, 2002, 2003). Therefore, cold-water refugia have not been created in the impoundment during the 1999 through 2002 sampling seasons.

The SCWA study compared water temperature data with standards proposed by the NCRWQCB (2000) to generally characterize habitat in this portion of the lower river. These standards recommend that the maximum weekly average water temperature for rearing juvenile steelhead should not exceed 17.8ºC and the maximum weekly water temperature should not exceed 23.9ºC. Site-specific temperature tolerance data are not available for salmonids in the Russian River basin, and these criteria may be conservative.

In 2000, during the peak smolt emigration period (mid-April through mid-May), weekly average water temperatures ranged from 16.1°C to 17.4°C, which are suitable for smolt emigration. Water temperatures increased rapidly to over 20.0°C in May and ranged from 20.9°C to 23.6°C in June. Compared to the proposed water temperature standards for the Russian River, these temperatures were suboptimal for a portion of the smolt emigration period and steelhead rearing period. However, suboptimal temperatures were documented upstream of the influence of the impoundment as well as within the impoundment, which indicates natural warming in this portion of the mainstem and results in high summer water temperatures.

In spite of the high temperatures, juvenile steelhead were captured in Wohler Pool during an August 2000 electrofishing survey and were observed by video monitoring in the fish ladders throughout the summer. Healthy-appearing Chinook salmon and steelhead smolts were captured in Wohler Pool in 2001, even when maximum daily surface temperatures were as high as 25.2°C. Steelhead juveniles were also documented in the Wohler Pool throughout the summer months.

Temperature Increases

Data from SCWA monitoring indicate the impoundment has only a small effect on the rate at which water warms (Chase et al. 2002). Data collected in 2001 are used to characterize the effects of the dam on water temperature and represent the thermal regime of Wohler Pool. Data from 2003 are similar to 2001 data, except there was a smaller increase in temperature in Wohler Pool (Chase et al. 2003).

To evaluate the amount of warming in Wohler Pool relative to natural heating and cooling trends, seven water temperature monitors were deployed in 2001, as follows:

- Station 1, located 11.5-km upstream of the dam, which is 6.4-km upstream of the influence of the dam.
- Station 2, located 5.1-km upstream of the dam, and at the upstream end of the Wohler Pool impoundment.
- Stations 3 and 4, located in the upper two-thirds and middle of Wohler Pool, respectively.
- Station 5, located at the dam.

- Station 6, located immediately below the dam.
- Station 7, located approximately 2.3-km downstream of the dam.

Stations 1 and 2 provided data about the natural heating/cooling of the mainstem upstream of Wohler Pool. Stations 3, 4, and 5 characterized thermal conditions within the impoundment. The 5.1-km reach between Stations 2 and 5 covers the region where thermal warming and cooling takes place in the impoundment.

The rate of increase in the average monthly surface temperature between Stations 1 and 2 ranged from 0.06°C to 0.10°C/km between June through September 2001. This resulted in an overall change of 0.4°C to 0.7°C per month over the 6.5-km distance during this time. Between Stations 2 and 5 (Wohler Pool) the rate of increase ranged from 0.04°C to 0.16°C/km during the same time-period. This resulted in an overall change of 0.2°C to 0.9°C over the 5.1-km distance in a month. Rates and magnitudes of change were smaller in bottom waters. Between Stations 6 and 7 (downstream of the dam), the rate of increase ranged from 0.10°C/km to 0.30°C/km, resulting in an overall monthly change of 0.4°C to 0.5°C over the 2.3-km distance.

Using the rate at which water temperatures increased in the unimpounded reach upstream of Wohler Pool (between Stations 1 and 2) as a baseline, the difference between the rates of increase in the Wohler Pool reach (between Stations 2 and 5) with and without the impoundment were estimated. This difference is the estimated increase in temperature above natural warming created by the Wohler Pool impoundment (Table 5-26). The analysis shows that during the warmest months (June through September), Wohler Pool could increase the average monthly water temperatures 0.1°C to 0.6°C above natural warming in surface waters, and from 0.3°C to 0.6°C in bottom waters. For example, average monthly water temperature would be increased by an additional 0.6°C in June of 2001, raising it from 20.6°C to 21.2°C. Applying water temperature scores for steelhead, there would be no change in score in surface waters and a decrease in bottom temperature scores from 3 to 2 in July and August.

Table 5-26 Estimated Increases in Water Temperatures above Natural Warming in the Wohler Pool (June to September 2001), and Change in Steelhead Temperature Score

Month	Estimated Increase Above Natural Warming (°C)	Estimated Effect on Average Monthly Water Temperature (°C)	Change in Steelhead Temperature Score
	Surface (0.5 m)		
June	0.6	20.6 to 21.2	2 (no change)
July	0.5	20.5 to 21.0	2 (no change)
August	0.3	20.3 to 20.6	2 (no change)
September	0.1	18.6 to 18.7	2 (no change)

Table 5-26 Estimated Increases in Water Temperatures above Natural Warming in the Wohler Pool (June to September 2001), and Change in Steelhead Temperature Score (Continued)

Month	Estimated Increase Above Natural Warming (°C)	Estimated Effect on Average Monthly Water Temperature (°C)	Change in Steelhead Temperature Score
		Bottom (3.0 m)	
June	0.4	20.5 to 20.9	2 (no change)
July	0.6	19.9 to 20.5	3 to 2
August	0.6	19.7 to 20.3	3 to 2
September	0.3	18.2 to 18.5	3 (no change)

Changes in Temperature under Flow Proposal

These data estimate the increase in warming for flows under baseline operations. Under the Flow Proposal, water temperature would increase, particularly downstream of the dam where summer flow would be reduced. Nevertheless, these data indicate the Wohler Pool impoundment results in only small increases in summer water temperature (0.1°C to 0.6°C per month over the length of the impoundment) above natural warming.

Under the Flow Proposal, summer flow in the Lower Russian River downstream of Dry Creek would be lower than under D1610 under current conditions, and summer water temperatures would be warmer (Table 5-27). Modeled flow and water temperatures are discussed in greater detail in Section 5.3. Predicted median water temperatures would be about half a degree warmer below Dry Creek under the Flow Proposal during the warmest summer months. At Hacienda Bridge, median water temperatures are predicted to be similar in June, but would increase in July through September. These model results suggest that summer water temperatures in Wohler Pool may be approximately half a degree higher as well, and water temperature downstream may be as much as 0.6ºC higher.

Table 5-27 Predicted Median Flow and Water Temperature in the Lower Russian River under Current Demand

	June	July	August	September
Below Dry Creek				
		Flow (cfs)		
D1610	320	292	282	246
Flow Proposal	236	174	179	179
		Temperature (ºC)		
D1610	21.2	22.6	22.2	20.5
Flow Proposal	21.6	22.9	22.7	20.9

Table 5-27 Predicted Median Flow and Water Temperature in the Lower Russian River under Current Demand (Continued)

	June	July	August	September
Hacienda Bridge				
		Flow (cfs)		
D1610	279	197	174	148
Flow Proposal	188	78	68	78
		Temperature (ºC)		
D1610	21.4	23.5	23.4	21.6
Flow Proposal	21.4	24.0	24.1	22.2

Based on modeled flow and water temperatures from the RRSM.

Effects of Temperature Changes on Salmonids

As discussed earlier in Section 5.2.3, a few steelhead may potentially rear in the area all year, but coho salmon have not been observed rearing through the summer near the Wohler Pool. Chinook salmon have not generally been observed rearing through the summer, although two Chinook salmon were captured in 2002, marking the first time this species was captured during electrofishing surveys. As salmonid smolts have generally migrated out by the end of June, increases in water temperatures are not likely to substantially affect smolt migration.

Temperature monitoring indicated that temperature in the late spring is optimal for growth of young salmonids in the Mirabel and Wohler areas. Steelhead YOY sizes doubled, and sometimes tripled, during the spring. Data indicate that summer water temperatures may be too high to support adequate growth, and juvenile steelhead leave the area by mid-July. However, healthy-appearing Chinook salmon and steelhead downstream migrants were captured during periods when maximum daily surface temperatures ranged up to 23.2ºC, and juvenile steelhead were captured and observed in the Wohler Pool throughout the summer months in 2002. During periods of elevated water temperatures (up to a temperature range where physiological stress occurs), juvenile salmonids may be healthy as long as sufficient food is available to support a higher metabolism (see Appendix C for a discussion of water temperature criteria). It is not known if steelhead YOY found in these areas during the spring or summer migrate to areas where water temperatures are cooler. It is possible that these steelhead YOY suffer mortalities as the quality of rearing habitat degrades with naturally high summer temperatures.

Temperature increases above natural warming in the Wohler Pool impoundment (upstream of the dam) are small under D1610 flow conditions. Under the Flow Proposal, summer water temperatures may be approximately half a degree higher than under D1610 (see Section 5.3 for an analysis of temperature in the Lower Russian River under the Flow Proposal). This could result in a change in the quality of rearing habitat for steelhead in the warmest summer months. However, summer water temperatures upstream of the impounded area are naturally high, and it is likely that poor rearing conditions may occur in this part of the mainstem during the hottest part of the summer, whether Wohler Pool is there or not.

5.2.3.4 Dissolved Oxygen in Wohler Pool

DO data from water quality profile monitoring in 1999 indicate the monitoring site at the dam had DO levels that ranged from a low of 6.7 mg/l to a high of 9.0 mg/l. DO levels at the upstream control site were slightly higher. Applying DO criteria for rearing, scores for all three species are 4 for levels greater than 6.5 mg/l and 5 for levels greater than 8.0 mg/l. Adequate DO levels were also found in subsequent years. Since scores of 4 or 5 were achieved during this monitoring period, it appears that DO levels have not been negatively affected by operations at the dam.

5.2.3.5 Predation in Wohler Pool and at the Inflatable Dam

Wohler Pool could increase habitat favorable for predatory fish species, which may increase the number of predators in this reach. Furthermore, juvenile fish migrating downstream past the dam could be concentrated in the notch of the dam or in the fish ladders as they pass, which would make them vulnerable to predation.

Predators sampled during electrofishing surveys from August 1999 to 2002 include Sacramento pikeminnow and non-native smallmouth and largemouth bass (Chase et al. 2003). Pikeminnow are native to the Russian River and are widespread upstream of Wohler Pool. They were observed in most large pools sampled during a 2002 snorkel survey (Cook 2003a). Striped bass (non-native) are known to occur in the Lower Russian River, but only two individuals have been captured in the study area during 4 years of sampling. Wild and hatchery salmonids have been collected in relatively low numbers, primarily in Wohler Pool.

Two of the most important factors that affect the risk of predation for salmonids are abundance and size of the predators. Small predators would find it difficult to prey on salmonid smolts. Zimmerman (1999) found that the maximum length of salmonids consumed by adult smallmouth bass and northern pikeminnow was linearly related to predator length (the northern pikeminnow and Sacramento pikeminnow are closely related), and that smallmouth bass consumed smaller juvenile salmonids than pikeminnow. The mean maximum length of salmonids consumed in the Zimmerman (1999) study was 119 mm FL (40 percent of predator length) for smallmouth bass and 167 mm FL (43 percent of predator length) for northern pikeminnow. Based on his regression, a 200-mm FL smallmouth bass can consume a 100-mm FL salmonid, and a 400-mm FL smallmouth bass can consume a 138-mm FL salmonid. Similarly, a pikeminnow between 250 mm to 530 mm FL can consume salmonids ranging from 116 mm to 220 mm FL. Based on a literature review conducted for the Mirabel sampling program, fish are generally not part of the diet for pikeminnow that are less than 200 mm. For pikeminnow 200 to 300 mm FL, fish are a small portion of the diet, and for those greater than 300 mm FL, fish are a significant part of their diet (Chase et al. 2003). The largest predators captured to date have been a 430-mm FL smallmouth bass (captured in 2003), a 726-mm FL pikeminnow (2003), and a 460-mm FL largemouth bass (2002).

Moyle (2002) reports that Sacramento pikeminnow greater than 200 mm standard length (SL) feed primarily on fish. Under natural conditions, Sacramento pikeminnow feed largely on nonsalmonid fishes. However, they may have a significant impact on salmonids where anthropogenic factors create situations that reduce the ability of juvenile salmonids to avoid predation, such as below dams, and they can travel large distances to feed (Moyle 2002).

The 1999 reconnaissance sampling program data provided an indication of the size of salmonids. Scale sample analysis indicates that steelhead primarily emigrate at Age 2+. In addition to steelhead and Chinook smolts, some steelhead YOY were captured in 1999 and 2000. Data indicate that some steelhead smaller than 60 mm (NOAA Fisheries definition of fry-sized) were present in early April, but that average sizes of steelhead were larger than 60 mm by the end of May, and greater than 80 mm by the end of June (Chase et al. 2000).

Chinook salmon emigrate through the Wohler Pool at an average of 90 mm FL (range approximately 35 mm to 140 mm), and steelhead at 175 mm (range 145 mm to 250 mm) (Chase et al. 2002). Chinook salmon averaged approximately 35- to 40 mm FL during the first few weeks of their life in 2002, then quickly grew to approximately 80 mm by mid-April. Chinook salmon emigrating in the spring would potentially be most vulnerable. Steelhead YOY rearing in the impounded area in the spring may also be at a greater risk. Steelhead YOY became abundant in mid-April 2002, at an average of approximately 40-mm FL. The average size of steelhead YOY increased from 44 mm to 84 mm between April and June 2000.

The data suggest that pikeminnow attain a size sufficient to prey on Chinook salmon smolts at the beginning of their third year of life (Age 2+). Pikeminnow Age 4+ or older are large enough to prey on both Chinook salmon and steelhead (Chase et al. 2001).

Boat electrofishing, conducted in August 1999 to 2002, sampled the fish community in the four reaches near the inflatable dam (see Section 5.2.3.2 for reach locations). The abundance of pikeminnow greater than 200-mm FL in the study area appears to be relatively low (Table 5-28). In 1999, 3 of 13 pikeminnow captures were large enough to prey on salmonid smolts. In spring 2000, a spot electrofishing survey captured two large pikeminnow. Because no tagged pikeminnow were recaptured during the second phase of the sampling program, it was not possible to estimate the population of pikeminnow longer than 200 mm FL. Several large pikeminnow were captured in 2001 and 2002. Although few adult pikeminnow were captured over the 4 years sampled, they are a long-lived species (up to 16 years [Moyle 2002]), and were large enough to feed on Chinook salmon and steelhead smolts.

In the same 1999 study, smallmouth bass averaged 85 mm FL in August of their first year and 179 mm in August of their second year. Growth rate of these fish determined by back-calculating length, gives an estimate as to what age smallmouth would become large enough to feed on Chinook salmon smolts. Smallmouth bass likely attain a size sufficient to prey on Chinook salmon at Age 2+.

Table 5-28 Size and Age of Sacramento Pikeminnow Captured in August Surveys (1999 to 2002) in Russian River Reaches 1 through 4

Age Class[1]	Average Length (mm FL)	Length Range (mm FL)	N[2]
Sacramento Pikeminnow (Average over the 1999 to 2002 August Sampling Season)[3]			
0+	66	35–95	161
1+	139	110-175	75
2+	252	195-300	15
3+	353	320-385	11
4+	459	410-455	6
Age 5+	531	515-555	8
Age 6+ or older	660	590-710	10

1 Ages based on length-frequency histogram and scale analysis (Chase et al. 2003).

2 Normally, younger age classes would be expected to have larger numbers of fish than older age classes within a population.

3 In the 2002 sampling season, in addition to the pikeminnow caught during the regular electrofishing sampling event, 15 additional pikeminnow greater than 200 mm FL were captured during a "predator" sampling event (20 total for the season).

Smallmouth bass were the most abundant species inhabiting the study area. Although many YOY fish were captured, no smallmouth bass large enough to prey on steelhead smolts and very few large enough to feed on Chinook smolts were captured in the years surveyed (Table 5-29). The low number of older smallmouth bass could be due to high bass YOY mortality, or to a high rate of emigration out of the study area. When the dam is deflated in the winter, recruitment of the smallmouth bass to older age classes may be low because a return to free-flowing conditions in the Russian River may limit juvenile survival.

Very few largemouth bass were captured, and abundance was highest in Reach 1 in all years sampled. Age 2+ fish may be large enough to feed on at least the smaller-sized emigrating Chinook salmon smolts.

Table 5-29 Smallmouth and Largemouth Bass Large Enough to Prey on Salmonids that were Captured in August Surveys (1999 to 2002) in Russian River Reaches 1 through 4

Age Class[1]	Average Length (mm FL)	Length Range (mm FL)	N/year
Smallmouth Bass			
2+	267	220-310	11-46
3+	336	300-380	2-6
4+	389	375-405	1-3
Largemouth Bass			
2+	192	175-220	0-5
3+	254	250-255	0-2
4+ or older	388	310-460	0-3

1 Ages based on length-frequency histogram and scale analysis (Chase et al. 2003).

SCWA electrofishing data from 1999 to 2002 showed that very few adult pikeminnow and smallmouth bass were present, despite an increase in pool habitat. Catch per unit effort (CPUE) is an indicator of a species' relative abundance and can be used to compare data between sampling sites of unequal sampling effort (e.g., length, time sampled). A comparison between reaches shows that CPUEs for large (Age 2+ or greater) Sacramento pikeminnow and smallmouth bass were similar between reaches in 2001 (Chase et al. 2003).

Evaluation of Predation Risk

The risk of predation is evaluated in three components: 1) the extent to which a project operation or structure concentrates prey in an area where predators are present; 2) potential changes in predator access to salmonid populations; and 3) project effects on water temperature, which may affect the risk of predation on juvenile salmonids. These criteria are applied to Wohler Pool and the dam. Finally, the components are synthesized for an overall risk assessment.

For the first component, the data suggest that while juvenile predators, particularly smallmouth bass, may be relatively abundant, predators that are large enough to prey on steelhead or salmon smolts are not. There are no features within Wohler Pool that concentrate salmonids. Therefore, the score for Wohler Pool is 4. Because migrating salmonids are concentrated at the inflatable dam when they pass (notch and fish ladders), the score is 3 (Table 5-30). Although the dam may briefly concentrate migrating fish in the notched configuration, the 2002 and 2003 findings suggest that the notch significantly reduces forebay residence time and that fish do not concentrate near the notch or in the forebay.

Table 5-30 Predation Evaluation Scores for the Inflatable Dam – Structural Component

Category Score	Evaluation Criteria	Current Operations Score*
5	No features that concentrate salmonids or provide cover for predators, concentrations of predators not found.	
4	No features that concentrate salmonids, predator cover near, predators in low abundance locally.	Wohler Pool (Co, St, Ch)
3	Features that concentrate salmonids, no predator cover nearby, predators in medium to low abundance locally.	Inflatable Dam (Co, St, Ch)
2	Features that concentrate salmonids, predator cover nearby, predators in medium to low abundance locally.	
1	Features that concentrate salmonids, predators abundant locally.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Only small numbers of smallmouth bass are found in the Wohler Pool despite the large numbers of juveniles. It is possible that the seasonal nature of the impoundment limits success of the juvenile bass population. Perhaps juvenile bass reproduction can be successful when the dam is inflated, but a return to free-flowing riverine conditions in the wet season makes it difficult for the young fish to survive.

The second component assesses predator access. Because the operation of the inflatable dam does not affect access for predators, this component of the evaluation criteria does not apply. Predators are able to pass through normal river flows when the dam is deflated, and may still pass through the fish ladder when the dam is inflated. Native and introduced warmwater predators were already established in the mainstem Russian River prior to use of the inflatable dam. Therefore, passage of predators through the fish ladder is not likely to introduce a new risk.

The third component assesses habitat conditions and, in particular, the suitability of temperatures for warmwater predators. SCWA monitored the temperatures in the impounded area of the dam (Wohler Pool) and reaches above and below, and estimated the increase in water temperature above natural warming that occurs in Wohler Pool (Chase et al. 2003). The average monthly water temperatures of surface waters in the impoundment would result in a score of 2 and in bottom waters, scores of 2 and 3 (Table 5-26). The estimated average monthly increase above natural warming ranged from 0.1 to 0.6°C, which suggests natural warming is a much more significant contributor to high summer water temperatures than project operations.

While the inflatable dam does not appear to significantly increase water temperatures favorable to warmwater predators, it increases the amount of predator habitat by significantly increasing the percentage of pool habitat above the dam for part of the year. Wohler Pool may function as a nursery for younger age classes of smallmouth bass and pikeminnow. Once deflation occurs, these younger age classes could disperse to other areas of the river and help sustain local populations. However, other nursery areas exist in the lower Russian River or in tributary habitat as well, and populations were established prior to operation of the dam. Because Wohler Pool may form relatively favorable summer/fall habitat compared to free-flowing, upstream or downstream mainstem reaches, data on species composition within the pool provide a conservative surrogate to estimate the overall risk of predation to juvenile salmonids. SCWA electrofishing data from 1999 to 2002 showed that very few adult pikeminnow and smallmouth bass were present, despite an increase in pool habitat. Wohler Pool does not provide additional year-round juvenile or adult habitat. The best available information suggests that Wohler Pool provides additional early rearing habitat that may help sustain local populations of predatory fish, but the data do not indicate the presence of Wohler Pool increases the overall carrying capacity of this portion of the mainstem.

In summary, pool habitat that would favor warmwater predator communities is created above the inflatable dam, but predators large enough to prey on juvenile salmonids have been found in only limited numbers. Although few pikeminnow were captured during all years sampled, they can attain a size large enough to feed on both Chinook salmon and steelhead smolts. Smallmouth bass were the most abundant species sampled in the study area. No smallmouth bass large enough to prey on steelhead smolts and very few smallmouth bass large enough to feed on Chinook smolts were captured. Data from sampling indicate that most of the predators sampled in this habitat were not large enough to be a significant threat to juvenile salmonids.

Yet even without the inflatable dam, warmwater species that prey on salmonids would be present. The operation of the dam does not introduce new predators to an area where they have not traditionally been. Water temperatures are suitable for warmwater predators, but operation of the dam increases water temperatures only slightly above natural warming. Salmonids are not concentrated in Wohler Pool. The inflatable dam may briefly concentrate migrating fish in the notched configuration, but 2002 and 2003 study results suggest that the notch significantly reduces forebay residence time and that fish do not concentrate near the notch or in the forebay. Overall, the inflatable dam may slightly increase the risk of predation on listed salmonid juveniles by increasing the amount of predator habitat and concentrating fish in the notch or fish ladder when they pass. But risk due to project operations is likely to be low.

5.2.4 Maintenance Activities

5.2.4.1 Inflatable Dam

Before the dam is raised, it may be necessary to remove gravel that has accumulated during the winter on top of the dam and in the fish ladders, although it has not been necessary in recent years. This activity could increase sediment input to the river or potentially entrain juvenile salmonids. This practice would most likely occur in the spring when juvenile salmonids of all three species are present.

A portable suction dredge removes accumulated gravel and the dredge discharge is routed to a temporary siltation (settling) pond to prevent turbid water from reaching the river. The water is allowed to re-enter the river after the sediment has settled, and spoils are removed or stored out of the flood plain. This practice is sufficient to reduce the risk of increasing suspended sediment concentrations in this vicinity of the river. Because suspended sediments are allowed to settle in a settling pond, the score for sediment containment is 3 (Table 5-31). Spoils are not placed where they would result in disturbance to the streambed or streambanks, so the score for upslope sediment control is 5. This maintenance activity would not likely put juvenile salmonids at risk.

In the area that the portable suction dredge is used, there is ample opportunity for young fish to escape the disturbance in the area. Therefore, the risk to juvenile salmonids in those years that the dredge is needed is likely to be low. However, because small salmonids may be present, there is the chance that occasionally one or more fish may be entrained by the suction dredge. The relatively small area that is maintained, combined with the fact that this maintenance activity is not needed every year, suggests that the number of fish subject to this risk is likely to be small.

Table 5-31 Sediment Containment Evaluation Scores for Inflatable Dam Maintenance

Category Score	Evaluation Category	Current Operations Score*
	Instream Sediment Control	
5	Project area does not require rerouting streamflow.	
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	Co, St, Ch
2	Limited sediment control.	
1	No sediment control.	
	Upslope Sediment Control (Spoils Storage)	
5	No upslope disturbance, or increase in upslope stability.	Co, St, Ch
4	Limited disturbance with effective erosion control measures.	
3	Moderate- to high-level of disturbance with effective erosion control measures.	
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel, or major changes in channel morphology.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

5.2.4.2 Vegetation Removal

Vegetation is controlled along access roads to levees associated with water supply operations. Vegetation is removed with an herbicide that is applied by hand and approved for aquatic use. Levee roads are mowed in the late spring each year. Juvenile emigration for all three species occurs during this time.

Vegetation removal does not occur on the streambank, but rather on roads upslope of the river. The main levee road on the west side of the river in the Mirabel area is approximately 250 feet from the river. It provides access to the Mirabel collector wells, infiltration basins, diversion caisson, and the west side of the inflatable dam. It also is used as an access location for periodic scraping of gravel bars that form under and upstream of the Wohler Bridge. The access road at Wohler is a dirt road used to access the Wohler collectors, and it continues south along the east side of the river to access the east side of the inflatable dam. This road is approximately 200 feet from the river. Both roads end at the river near the inflatable dam, but herbicides are not used on the road adjacent to the river. Because the roads are 200 or more feet from the river, this maintenance is not likely to affect the riparian vegetation adjacent to the river. Effects of vegetation control are scored to evaluate the use of an herbicide (Table 5-32). A score of 4 indicates that significant short-term effects from the use of this herbicide are not likely to occur. Because the active component of this herbicide is short-lived, application in upslope areas away from the stream may not result in any contact with the stream.

Table 5-32 Vegetation Control Scores for Levee Roads

Category Score	Evaluation Category for Herbicide Use	Current Operations Score*
5	No chemical release.	
4	Limited use of herbicide approved for aquatic use.	Co, Ch, St
3	Moderate to heavy use of herbicide approved for aquatic use.	
2	Use of herbicide not consistent with instructions.	
1	Herbicide not approved for aquatic use.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Improper use of this herbicide could result in contamination of the water and harmful effects on listed species. However, SCWA has a training program for maintenance workers and with prescribed use, the risk is minimal.

5.2.5 Water Treatment and Facility Maintenance Substances

Substances used to treat water include chlorine, an orthopolyphosphate compound, and caustic soda (sodium hydroxide). Each substance is contained in accordance with strict regulations, and would not be released under normal conditions. Any significant risk to listed species would be due to accidental spills. For the substances discussed below, the risk of an accidental spill and subsequent exposure to fish in the river is minimized by in-place and up-to-date Spill Prevention, Containment, and Control (SPCC) plans.

5.2.5.1 Chlorine

Chlorine is normally delivered to SCWA's chlorine buildings in pressurized cylinders that are constructed in accordance with strict regulations and that are capable of withstanding severe shock if they are dropped. SCWA buildings that house chlorine are equipped with leak-detection alarm systems and are located at a considerable distance from the river (approximately 250 yards). These measures are likely to reduce the likelihood of accidental releases of concentrated chlorine to the river. Furthermore, calcium hypochlorite is currently used at the Sebastopol Road and Todd Road well sites, eliminating the need for chlorine gas cylinders at the sites. This system will be installed at the Occidental Road well in the future.

Minor amounts of chlorinated water are discharged from the Ranney collector wells and other nearby facilities. Water from motor cooling lines is discharged at an estimated rate of approximately 5 gpm when the pump motors are running. This discharge water flows into the settling and infiltration ponds at the Mirabel facilities, and into the Russian River at Wohler. These incidental discharges and the pipeline discharges are covered under a waiver issued by the NCRWQCB. SCWA is looking into other options for cooling to alleviate this discharge.

Maintenance of the water storage tanks requires that the tanks be emptied periodically. A portion of the water is released to surface water drainage. SCWA maintenance staff adds a dechlorinating chemical to eliminate any chlorine residue in the discharge. If water levels in the tank unexpectedly rise too high, overflows may occur. In this case, water with a chlorine level of approximately 0.6 ppm may be discharged to surface water drainage.

In general, normal operation and maintenance activities are performed with trained personnel and under stipulations and regulations provided by permits. Because chlorine would be in the form of a gas, if spilled, the likelihood of it entering the water in severe concentrations is limited. A catastrophic spill in the water from storage tanks could have severe consequences but would be limited in area. The SCWA SPCC plan minimizes this to nearly no risk. Normal operations do not appear to present a significant risk to the threatened fish species of the area.

Accidental spills from the water transmission system have the potential to introduce chlorinated water to streams in the watershed. SCWA has added dechlorination baskets and alerts to each of 17 valves that could result in a spill of potable water if they fail. Because chlorine would be removed from the water, there would be no negative effects to salmonids. An alert would notify SCWA if there is a problem so that it could be corrected.

5.2.5.2 Caustic Soda

Caustic soda is delivered by tanker trucks as a solution of 50 percent water and 50 percent caustic soda. Storage facilities are designed to keep the substance contained. The Wohler pH control building is located approximately 250 yards from the river, and the River Road pH control building is approximately 200 yards from Mark West Creek. The concrete masonry walls of the pH control buildings are designed to provide secondary containment in the event a leak occurs. Although a catastrophic spill that entered the river would be serious, the SPCC measures should be adequate to minimize the risk of an accidental spill to nearly nothing, and distance from the river further minimizes the risk to salmonids.

5.2.5.3 Orthopolyphosphate

A pilot treatment system is in place at the Todd Road well that adds a small dose of an orthopolyphosphate compound to the well water. This treatment is used to eliminate the hydrogen sulfide odor that occurs at all three wells. The SPCC plan provides maximum protection from an accidental spill and the risk is little to none.

5.2.5.4 Hydrocarbons

The only significant potential effect related to hydrocarbons is diesel fuel storage. A catastrophic spill into the Russian River would have serious effects. Because of the adherence to local and federal regulations and guidelines (i.e., SPCC plans), it appears highly unlikely that a major spill would occur. Approximately 31,000 gallons of diesel fuel are stored adjacent to the standby generators at Wohler and Mirabel for use in powering standby generators. Both diesel storage locations are approximately 250 yards to 300 yards from the Russian River and are in above-ground, double-containment tanks, which would indicate that if a spill did occur it would be unlikely to enter the Russian

River. Concrete block walls around fuel tanks provide additional containment capability. Fuel tanks are designed, manufactured, and constructed in accordance with the Uniform Fire Code, the Uniform Building Code, and applicable local codes and ordinances. Spill prevention and response is outlined in the SCWA SPCC plan, which is kept updated per state and federal regulations.

5.2.6 Water Supply and Transmission System Project

SCWA is in the process of environmental review of the program-level impacts of the WSTSP. The facilities proposed under the WSTSP are included in this BA as an approximate future model against which effects to salmonids from future water supply development may be analyzed. The actual water supply facilities and diversions from the Russian River, which SCWA's Board of Directors may approve in the future, may differ from those contemplated in the WSTSP.

The WSTSP would implement water conservation measures to save approximately 6,600 AFY; increase the amount of water diverted from the Russian River (rediversion of stored water and direct diversion of winter flow) from 75,000 AFY to approximately 101,000 AFY; and increase the transmission system capacity from 92 mgd to 149 mgd.

Diversion facilities would include Ranney-type collector wells, conventional wells, infiltration ponds, surface-water diversion structures, water treatment facilities, pumps, connecting pipelines, and appurtenances. As with the existing facilities, potential effects of these facilities include changes to instream flow, passage past project facilities for adult and juvenile salmonid migration, water quality-related effects and alteration of habitat from construction, and operation and maintenance activities.

Distribution facilities would include pipelines and booster pump stations, as well as an additional 55.5 million gallons of storage (steel storage tanks). As with existing facilities, potential effects may be related to use of water treatment and facility maintenance substances.

5.2.6.1 Additional Diversion Facilities

Additional diversion facilities would have the potential to alter groundwater or instream flow. However, under the Flow Proposal, instream flow would be managed to improve flow-related habitat for fish. Effects of the proposed water management are discussed in Section 5.3.

The additional diversion facilities have the potential to affect adult and juvenile salmonid migration past the facilities. Under the proposed project, all diversion facilities would be equipped with fish screens that meet NOAA Fisheries and CDFG fish-screen criteria for fry and juvenile salmonids. Therefore, fish would pass without injury or delay. Furthermore, any additional infiltration ponds would likely be located away from the stream, or graded and designed to minimize the risk of entrapment during high-flow storm events.

Construction of additional facilities such as collector wells and infiltration ponds would occur away from the stream and would have no effect on salmonids or their habitat. Construction of surface water diversions could occur and if constructed would include measures that minimize effects to salmonids and their habitat. Sediment control during construction would be implemented as appropriate for a particular site. Therefore, construction activities would unlikely to result in harmful sediment input to the waterway.

Construction of additional facilities is likely to result in removal of vegetation, and riparian vegetation may be affected. Under the proposed project, native vegetation would be planted to mitigate for the loss of existing vegetation.

Vegetation maintenance activities would be implemented as described for existing facilities. Significant short-term effects from the use of this herbicide are not likely to occur, and as with existing maintenance activities, the score is 4 (Table 5-33).

Table 5-33 Vegetation Control Scores for Levee Roads for Additional Diversion Facilities

Category Score	Evaluation Category for Herbicide Use	Current Operations Score*
5	No chemical release.	
4	Limited use of herbicide approved for aquatic use or over water.	Co, Ch, St
3	Moderate to heavy use of herbicide approved for aquatic use or over water.	
2	Use of herbicide not consistent with instructions.	
1	Herbicide not approved for aquatic use or over water.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

5.2.6.2 Additional Distribution Facilities

Substances used for maintenance or water treatment would be the same as for existing operations. Protocols for their use and containment would be implemented in accordance with strict regulations. The risk of an accidental spill and subsequent exposure to fish in the river would be minimized by in-place and up-to-date SPCC plans.

5.3 FLOW AND ESTUARY MANAGEMENT

This section evaluates the effects of the Flow Proposal on flow, water temperature, and DO in Dry Creek and the Russian River. The Flow Proposal is designed to improve summer rearing habitat in the Russian River and Dry Creek by reducing water velocities that are currently unsuitably high. This section also assesses the effects of proposed water management on the Estuary and evaluates a proposed change in the artificial breaching program. The Flow Proposal is designed to improve summer rearing habitat in the Estuary by keeping the sandbar closed.

5.3.1 Flow Proposal

The current flow regime in the Russian River and Dry Creek is determined by the requirements of D1610. A *Flow Assessment Study* conducted jointly by SCWA, USACE, NOAA Fisheries, CDFG, and ENTRIX found that D1610 flows were higher than optimal in both streams for the rearing lifestages of coho salmon, steelhead, and Chinook salmon (ENTRIX 2003b, Appendix F). The results of this study are provided in Appendix F. Based on the study findings and the desire to improve habitat conditions for these species, while continuing to meet regional water supply needs, SCWA has developed an alternative water management scenario called the Flow Proposal. The Flow Proposal is described in Section 4.3. Additional details on operations and proposed permit terms are provided in Appendix B.

The Flow Proposal is designed to provide improved rearing conditions by reducing flows in Dry Creek and the Russian River downstream of Coyote Valley Dam, while continuing to meet water demands for the communities served by SCWA. As the water demands increase to levels anticipated from general plans applicable to SCWA's service area, additional measures will need to be implemented to continue to provide good rearing conditions in the Russian River and Dry Creek. The "Additional Measures" are described in Section 4.3.2.4. These Additional Measures include a range of alternative actions that could be implemented to meet future water demands (at buildout) anticipated by the counties and communities within the SCWA service area, as contemplated by the WSTSP.

For purposes of this analysis, water demand at "buildout" is the amount of water that would have been delivered by SCWA assuming construction of all WSTSP facilities. As noted earlier, although it is uncertain whether the WSTSP will be carried out as described in the original WSTSP EIR, inclusion of the proposed WSTSP in the current BA allows future effects to the threatened salmonid species to be evaluated based on more specific, defined assumptions than would happen otherwise. The actual water supply facilities and diversion from the Russian River, which SCWA's Board of Directors may approve in the future, may differ from those contemplated by the WSTSP. But the inclusion of the WSTSP future water supply assumptions nevertheless provides a rough, approximate model for future analysis of effects to salmonids from future water supply development.

The Flow Proposal was evaluated using the SCWA's RRSM and RRWQM models. These models predict daily flow, temperature, and DO values at specific locations along the Russian River and Dry Creek, using a given set of starting conditions, historical and projected future demand patterns, climatic conditions, and local runoff in different watershed areas (Flugum 1996). The Russian River locations analyzed include Ukiah, Hopland, Cloverdale, Healdsburg, and Hacienda Bridge (near Guerneville). In Dry Creek, model output was analyzed in two locations: below Warm Springs Dam (Upper Dry Creek) and above the confluence with the Russian River (Lower Dry Creek). These simulations were conducted using the hydrology for the period from 1910 to 2000. Each month is assigned a water supply condition, as described under D1610 (see Section 3.4.1) based on storage levels in Lakes Pillsbury and Mendocino. Model runs were made for the Flow Proposal and D1610 under current and future (buildout) water demand levels.

5.3.2 Comparing Streamflow under Flow Proposal vs. D1610

Median monthly flows and median monthly water temperatures were compared to evaluate the expected change in streamflow under the Flow Proposal. The median monthly values are the median daily flow or temperature that occurs for that month considering all of the days during the 90-year period of simulation (1910 to 2000).

The evaluation was conducted for *all* water supply conditions and for *dry* water supply conditions. *All* water supply conditions include all data regardless of the water supply category. The term "*all*" does not have a legal definition, as do "*normal*," "*dry*," and "*critically dry,"* but is the composite of all three conditions. The *all* water supply conditions are strongly reflective of *normal* water supply conditions, which occur 70 to 90 percent of the time in the months analyzed.

In this section, the *dry* water supply condition includes both *dry* and *critically dry* water supply conditions as defined under D1610. The values reported for the *dry* water supply condition reflect the conditions that exist only during those "*dry*" and "*critically dry*" months, and are a subset of *all* water supply conditions. These conditions occur in about 10 to 30 percent of months. *Dry* water supply conditions were used in the analysis, since water management of the system changes under these conditions and may affect salmonids differently. *Critically dry* water supply conditions were not evaluated separately because they occur infrequently, representing only 1 to 6 percent of months during the summer period.

5.3.3 Comparing Salmonid Habitat under Flow Proposal vs. D1610

To assess effects of the Flow Proposal on salmonid habitat, conditions under the Flow Proposal were compared to the baseline (i.e., D1610) conditions. (The flows and temperatures present under D1610 are presented in Section 3.4). The evaluation criteria presented in Appendix C were used to evaluate the changes in habitat based on changes to the three parameters—flow, water temperature, and DO. Each of the parameters was scored based on the needs of the lifestage being evaluated. Scores range from 0 to 5, with 0 being the poorest and 5 being optimal. The scores are described in the text as follows: potentially lethal (0), marginal (1), poor (2), good (3), excellent (4), and optimal (5). For each species, a pie chart was prepared showing, by location and lifestage, the frequency of scores that would occur for each parameter within the appropriate range of dates for that lifestage.

In the following sections, the effects of the Flow Proposal on salmonid habitat are discussed relative to the conditions under D1610. This section describes how habitat conditions would differ under both current and buildout water supply demand levels. Because the Flow Proposal would affect flows predominantly during the summer months, the discussion focuses on the period from June through October. Flows are provided by natural rainfall patterns, and project operations have much less influence on flow levels during the winter and spring period. Potential effects during the wetter times of the year are discussed on a case by case basis when appropriate.

During June through October, the primary lifestages present in the Russian River system are rearing juvenile steelhead and coho salmon. In June, some steelhead and Chinook salmon smolts may be emigrating from the system, but most of these fish will already have passed downstream into the ocean. Small numbers of Chinook salmon adults have been observed migrating upstream as early as August under current flow and Estuary management practices. Most Chinook salmon do not begin their upstream migration until October, and under the proposed Estuary management scenario, Chinook salmon would not be able to enter the Estuary before the onset of fall rains.

The reach between Ukiah and Cloverdale provides the best mainstem habitat for salmonids (B. Cox, CDFG, pers. comm. 2001). This reach has suitable water temperatures and better channel structure (more habitat complexity) than areas downstream of Cloverdale. The water quality modeling and field data collected by SCWA indicate that water temperatures are generally too warm to provide suitable over-summer habitat for salmonids at Healdsburg and Guerneville. The mainstem Russian River above Cloverdale is used by rearing steelhead during the summer months (Cook 2003b). Coho salmon are not thought to use the mainstem except as a migration corridor to tributary streams. Steelhead also use the tributaries extensively for all lifestages. Chinook salmon use the mainstem and some of the larger tributaries for all lifestages. Chinook salmon, however, do not remain in fresh water during the summer months from July through September or October, except as noted above.

Current operations provide good water temperature conditions throughout Dry Creek for all three species. Good structural habitat is scattered throughout Dry Creek.

5.3.4 Considerations and Issues by Lifestage

5.3.4.1 Upstream Migration

Upstream migration occurs generally between September and March for the three listed species. For these species to migrate upstream successfully:

- the sandbar at the mouth of the Estuary must be open,
- the flows in the river must be high enough to supply adequate depth for fish to migrate upstream past shallow riffles, but not so high that the water velocity creates a barrier, and
- water temperatures must be suitable for the maturation of the gametes (eggs and sperm) being carried by the adults.

Chinook salmon begin migrating into the Russian River sooner than coho salmon and steelhead, with the rare individual having been observed as early as August under the current management of the system. This has made Chinook salmon the most susceptible to conditions of low flow and high temperatures during upstream migration. Under D1610, the water levels in the Estuary have been managed to prevent localized flooding along the lower river by mechanically breaching the sandbar at the mouth of the Estuary. The artificially open condition has allowed Chinook salmon to migrate upstream earlier than they could have historically, when flows and water temperatures were not suitable for upstream migration. This may have led to lowered spawning success because of longer migration times, due to delays at critical riffles because of lower flows. This would also result in additional stress on the adults and lower rates of gamete viability due to higher temperatures.

Coho salmon and steelhead begin migrating upstream in November and January, respectively. During this time, natural runoff has usually increased because the rainy season is underway, and the operation of the project reservoirs has much less influence on the flows in the mainstem. In addition, during this time, air and water temperatures have declined substantially from their summertime highs to levels that are acceptable for upstream migrants.

Mid-October Breach Under Flow Proposal

Under the Flow Proposal, the Estuary will be managed as a closed system; that is, the sandbar at the mouth of the Estuary will remain closed during the summer, as it would be naturally. With the reduced flows, the sandbar would remain closed until early storms elevated flows. If early storms did not occur, the bar would be opened when USACE begins to release water from Lake Mendocino to bring these reservoirs down to flood control levels for the winter. This typically occurs around mid-October. The closed sandbar would prevent Chinook salmon from entering the Russian River before this time. A closed Estuary would benefit Chinook salmon, because they would not be exposed to the warmer temperatures that occur before October. Also, their migration would not be delayed by the lower flows that occur in August and September, before the rainy season begins.

5.3.4.2 Spawning

Spawning typically occurs between November and March for the three species. Chinook salmon and coho salmon spawn from November into January. Steelhead spawn from January through March. The flows required for successful spawning are those that provide adequate water depths over spawning gravels, and elevated velocities to wash away fine sediments while the fish are cutting their redds (i.e., nests in the gravels where salmonids lay their eggs). The velocities should be in a suitable range to allow fish to maintain their position without exhausting themselves. A minimum of approximately 0.6-foot of depth is necessary for spawning coho and steelhead, and about 0.8-foot of depth for Chinook salmon. Water temperatures during this time of year are typically very good to excellent for spawning, although temperatures may be warmer than optimal for early spawners in some years at some locations, as discussed below.

5.3.4.3 Incubation

Considering the three species together, the incubation period extends from November into April or perhaps May. This is the period from when the first eggs are laid until the last alevin (small salmonid fry) emerges from the gravel. Flows during incubation must be sufficient to keep the redds covered with water, although the water does not necessarily have to be as deep as it was for the adults to spawn in that location. Flows must also be sufficient to provide intergravel flow (flow through the gravels) to maintain the oxygen flow to the eggs and alevins and carry waste products out of the redd. This is aided to a large extent by the locations where the fish make their redds. These are typically in areas where the hydraulics naturally tend to promote intergravel flow, such as pool tailouts and riffles. Flows must not be so high as to scour the redds.

Water temperatures in the mainstem Russian River above Cloverdale are generally very good for incubation in *all* water supply conditions, although redds created in October may be exposed to very stressful water temperatures in the Upper Russian River. In *dry* water supply conditions, water temperatures are a little warmer, but would still provide good conditions in the mainstem above Cloverdale (although October water temperatures would still be quite warm). Alevins that stay in the redds until late April or May may be exposed to warmer-than-optimal temperatures above Cloverdale. Water temperatures in Dry Creek below Warm Springs Dam are generally good for incubation throughout the season, and, in Dry Creek above the Russian River, temperatures are good into May under both water demand scenarios.

5.3.4.4 Summer Rearing

This lifestage extends over the warmer portion of the year from June through October. This is the season when project operations predominantly affect flow conditions within the Russian River downstream of the Forks and in Dry Creek. Summer rearing applies to steelhead and coho salmon in their first year of life. The juveniles of these species spend one year or more in fresh water before emigrating to the ocean. This lifestage does not apply to Chinook salmon because Chinook salmon fry begin emigrating to the ocean within a few weeks of emerging from the gravel. Some Chinook salmon may still be in the river in June, but by the end of June, all have migrated downstream.

As previously discussed, the *Flow Assessment Study* (ENTRIX 2003b, Appendix F) conducted jointly by SCWA, NOAA Fisheries, CDFG, USACE, and ENTRIX found that D1610 flows in the Russian River and Dry Creek were higher than optimal for rearing salmonids. Because of this, both high temperatures and high flows are major concerns when evaluating the effect of flows on this lifestage.

5.3.5 CHANGES IN FLOW AND TEMPERATURE

The changes in flow and temperature described below are based on the median monthly flow and water temperature values, as determined from the daily flow and mean daily water temperatures estimated by the model. The median monthly values for flow and temperature for D1610 are shown in Tables 3-8 and 3-9, respectively. For the Flow Proposal, median monthly flow values are shown in Table 4-5, and median monthly temperature values are shown in Table 5-34. The median monthly values provide an index as to how the flows change from month-to-month and the flow value expected in a given month. They do not describe the complete range or distribution of flows and temperatures.

In evaluating D1610 and the Flow Proposal, the evaluation criteria were applied to each parameter for each day at each location. The frequency of scores is based on the entire record and describes the range of flow and water temperature values observed. Thus, the median flow may lead one to expect a particular score during a month, but the actual score may differ depending on how the full range of flows or temperatures is distributed.

Table 5-34 Median Monthly Temperature (^{o}C) Values Under the Flow Proposal

***All* Water Supply Conditions**												
Stations	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Ukiah	8.5	9.2	11.3	12.6	14.5	16.3	16.2	17.6	18.5	18.8	15.1	10.7
Hopland	8.5	9.4	11.7	13.4	16.1	18.5	19	19.7	19.5	18.7	14.9	10.6
Cloverdale	8.4	9.4	11.9	14	17	19.4	20.3	20.6	19.8	18.4	14.7	10.4
Healdsburg	8.5	9.8	12.6	15.6	19	21.8	23.8	23.5	21.6	18.5	14.2	10.1
Below Dry Creek	8.9	10.1	12.7	15.5	18.8	21.4	22.8	22.2	20.5	17.8	13.9	10.4
Hacienda	9	9.9	12.2	15	18.3	21.3	23.9	24	22.2	18.6	14.1	10.5
Warm Springs Dam	12.4	11.8	12.8	12.9	13.1	13.2	13.3	13.2	13.1	12.9	12.7	12.7
Lower Dry Creek	10.4	11	13	14.7	17	18.3	18.7	18.2	17	15.6	13.1	11.6

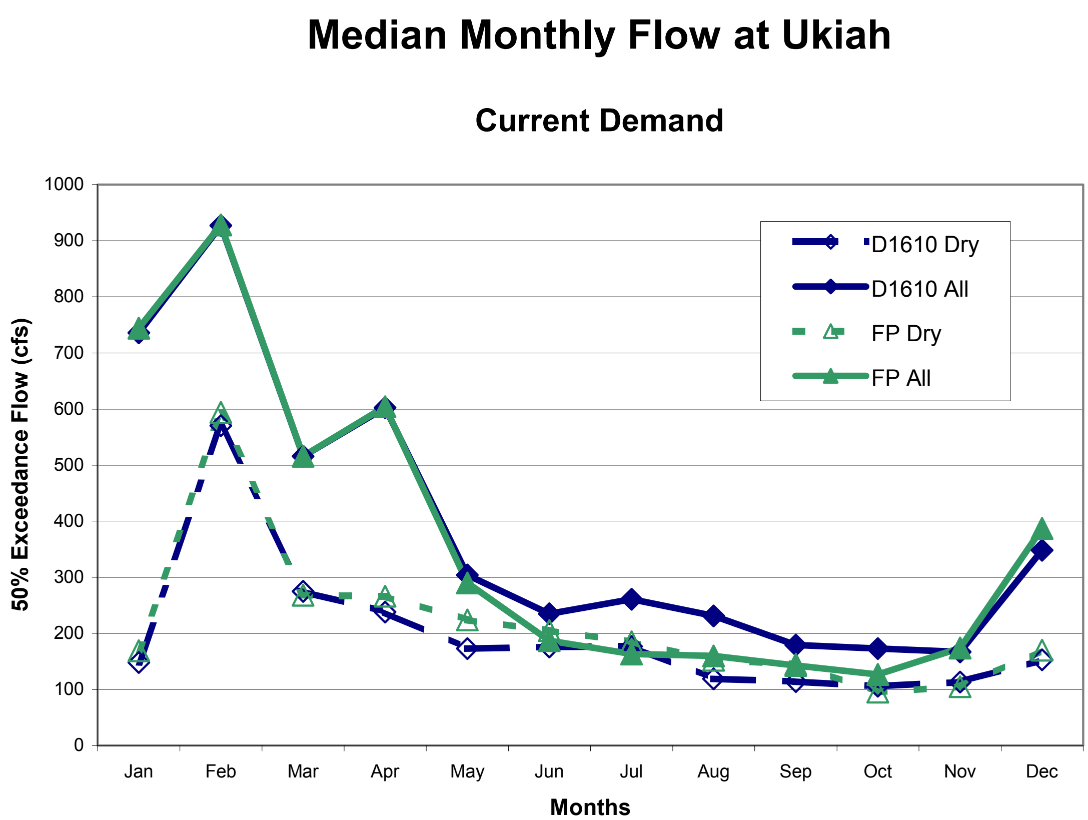
***Dry* Water Supply Conditions**												
Stations	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Ukiah	9.4	9.5	11.4	13	14.3	15.2	16.2	19.5	21.6	19.5	14.8	10.8
Hopland	9.6	9.7	11.9	14.3	16	17.6	18.6	20.6	21.2	19	14.5	11
Cloverdale	9.6	9.7	11.9	14.7	16.8	18.7	19.8	21	20.7	18.6	14.5	10.7
Healdsburg	9.4	10	12.7	16.1	19.2	21.5	23.7	23.1	21.4	18.6	13.9	10.1
Below Dry Creek	9.9	10.2	12.8	15.9	18.8	20.9	22.2	21.8	20.1	17.6	13.5	10.2
Hacienda	9.6	10	12.2	15.1	18.5	21.7	24.4	23.7	21.9	19	13.6	10.4
Warm Springs Dam	12.7	12.6	12.8	13	13.1	13.2	13.1	13.1	13	12.9	12.8	12.7
Lower Dry Creek	11.3	11.3	12.9	15.1	16.9	17.7	18.1	17.8	16.8	15.4	13.1	11.4

5.3.5.1 Flow

The *Flow Assessment Study* (ENTRIX 2003b, Appendix F) concluded that habitat for rearing salmonids could be improved if flows were reduced from levels that occur under D1610. This conclusion was reached for the mainstem from the Forks to Cloverdale and in Dry Creek. As described below, the Flow Proposal would reduce flows substantially compared to current operations under D1610, in order to improve rearing habitat.

Russian River

At Ukiah under *all* water supply conditions, median flows during the summer months (June through October) under D1610 range from about 260 cfs in July to about 175 cfs in September-October under current demand levels. Under the Flow Proposal, flows would drop to about 185 cfs in June and 130 cfs in October (Figure 5-3). During November through May, flows would be similar under the Flow Proposal and D1610, ranging from a median monthly flow of about 170 cfs in November to 925 cfs in February. Flows would differ by a maximum of about 11 percent during this time period.



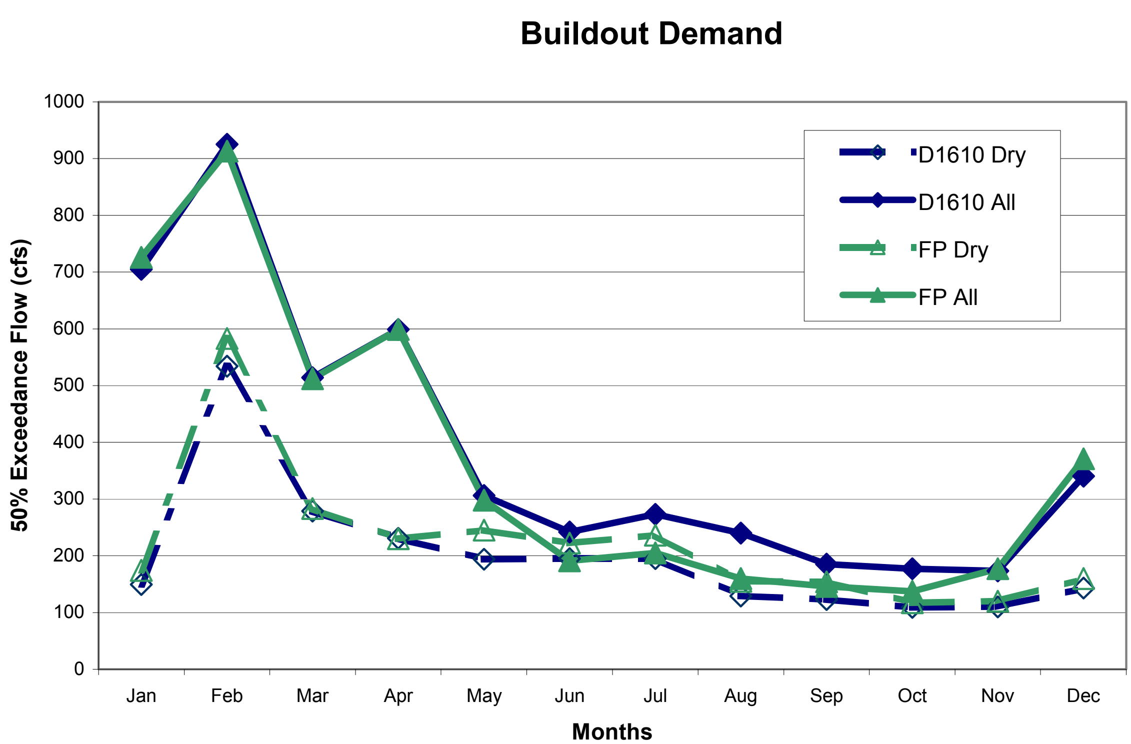


Figure 5-3 Median Monthly Flows in the Russian River at Ukiah under D1610 and the Flow Proposal

At Ukiah, under *dry* water supply conditions, the Flow Proposal median flows would range between 95 and 205 cfs during the June-October time frame, an increase of 5 to 30 cfs relative to D1610, except in October when flows would be about 10 cfs lower. During November through May, flows would be similar under the Flow Proposal and D1610, ranging from a median monthly flow of about 105 cfs in November to 595 cfs in February. The maximum differential between the two management scenarios would again be about 11 percent.

At Ukiah, under *all* water conditions, the Flow Proposal would provide flows 40 to 80 cfs lower than D1610 during June through October at buildout. Flows during this time frame would range from about 180 to 275 cfs under D1610 and from 135 to 205 cfs under the Flow Proposal (Figure 5-3). The Flow Proposal would provide flows 10 to 30 cfs higher at buildout than at current demand levels. These flows would remain lower than those that currently occur under D1610. Flows during November and May would be similar for the two management scenarios and would be about the same as under current demand levels.

Under *dry* water supply conditions, the Flow Proposal would result in flows 10 to 40 cfs higher than D1610 at buildout. This would occur because the Flow Proposal balances water supply from the two reservoirs differently than under D1610, to maximize habitat value in the Russian River and Dry Creek. Flows during November through May would be similar under the Flow Proposal and D1610, differing by a maximum of 5 percent in January.

The relative differences in flow in the Russian River would persist under both *all* and *dry* water supply conditions and in both demand scenarios. Under *all* water supply conditions, at both demand levels, flows tend to increase with distance downstream from Coyote Valley Dam to Healdsburg from November through May, and decrease with distance downstream from the dam from July through September. Flows are relatively constant throughout this reach in June and October. Under *dry* water supply conditions for both demand levels, this pattern is similar, except that flow decreases with distance downstream in June. Below Healdsburg, flows from Dry Creek enter the river, increasing flows downstream as far as the Mirabel diversion facilities, where SCWA rediverts water released from the reservoirs to meet water supply needs. The pattern of increasing or decreasing flows resumes below Mirabel.

Dry Creek

Summer flows in Dry Creek would be reduced by the Flow Proposal as well. At current demand levels for *all* water supply conditions, flows under D1610 range from about 80 to 105 cfs between June and October (Figure 5-4). Under the Flow Proposal, corresponding flows would range from about 55 to 75 cfs in the June-October time frame. Under *dry* water supply conditions, flows would increase over *all* water supply conditions for both scenarios. At buildout under D1610, flows would increase to range between 90 and 140 cfs for *all* water supply conditions and to 125 to 235 cfs under *dry* water supply conditions. Under the Flow Proposal, the flow increase would be much less, ranging from 55 to 90 cfs for *all* water supply conditions and 65 to 100 cfs for *dry* water supply

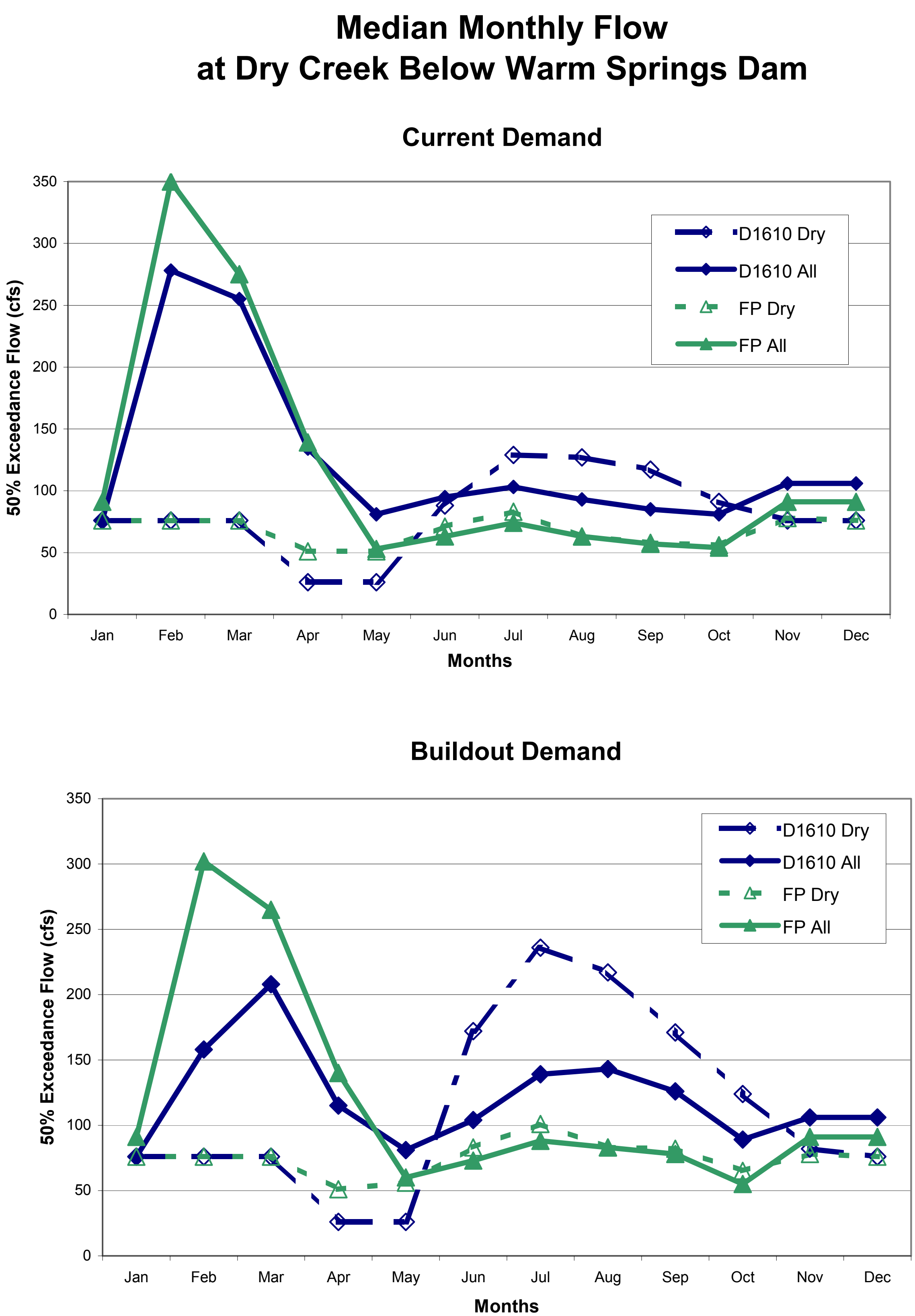


Figure 5-4 Median Monthly Flows in Dry Creek Below Warm Springs Dam under D1610 and the Flow Proposal

conditions. Under the Flow Proposal in *critically dry* water supply conditions (which occur only 2 percent of the time in summer) flow in Dry Creek would be much higher, ranging from 140 to 200 cfs. These flow conditions would severely reduce rearing habitat in Dry Creek, but are lower than what occurs under D1610 under dry water supply conditions, which occur six times more frequently.

Flows in Dry Creek during February and March (and to a lesser extent in January) would tend to be higher under the Flow Proposal than under D1610. This would occur because the lower summer flows would leave more water in the flood control pool at the end of the year. Thus, USACE would have to make larger releases during the runoff period to keep the reservoir level within the flood control pool. These larger flows would occur under both *all* and *dry* water supply conditions. Under *all* water supply conditions and current demand levels, flows in February and March would be 350 and 275 cfs, respectively, under the Flow Proposal, and 278 and 255 cfs, respectively, under D1610. Under *all* water supply conditions at buildout demand levels, flows in February and March would be 302 and 265 cfs, respectively, under the Flow Proposal, and 158 and 208 cfs, respectively, under D1610. Under *dry* water supply conditions, flows under the two management strategies would be similar during these months, about 75 cfs during both current and buildout demand levels. The Flow Proposal has higher flows than D1610 in April and May in *dry* water supply conditions, with flows of about 50 cfs, as opposed to 25 cfs under D1610.

5.3.5.2 Temperature

The changes in flow under the Flow Proposal will affect water temperatures. Lower flows generally result in higher water temperatures in the summer months. However, lower flows also decrease the rate at which the coldwater pool at the bottom of Lake Mendocino is depleted. This is seen in the pattern of temperatures in the mainstem Russian River below the dam. At Ukiah, under the Flow Proposal at current demand levels, water temperatures are warmer than under D1610 in June and July, but by less than 0.5°C, and cooler than D1610 during September and October, by as much as 2°C (Figure 5-5). In June and July, the lower temperatures occur because the lower flows under the Flow Proposal respond more quickly to ambient air temperatures than the larger volume of water under D1610. In September and October, the cooler temperatures occur because the large flows under D1610 drain the coldwater pool at the bottom of Lake Mendocino more quickly. This coldwater pool is depleted in September, and releases after this date reflect the warmer temperatures of the water flowing into Lake Mendocino. With the lower flows under the Flow Proposal, the coldwater pool is not depleted as quickly and cool water is available for release through September and into October, when ambient air temperatures begin to decline.

The difference in water temperature between D1610 and the Flow Proposal diminishes with distance downstream, with a maximum difference at Hopland of less than 1.5°C, and less than 0.5°C at Cloverdale. Further downstream at Healdsburg, the water temperatures under D1610 and the Flow Proposal are nearly identical. Below the confluence of Dry Creek and at the Hacienda Bridge, the Flow Proposal results in summer temperatures that are generally less than 0.5°C warmer than under D1610. These

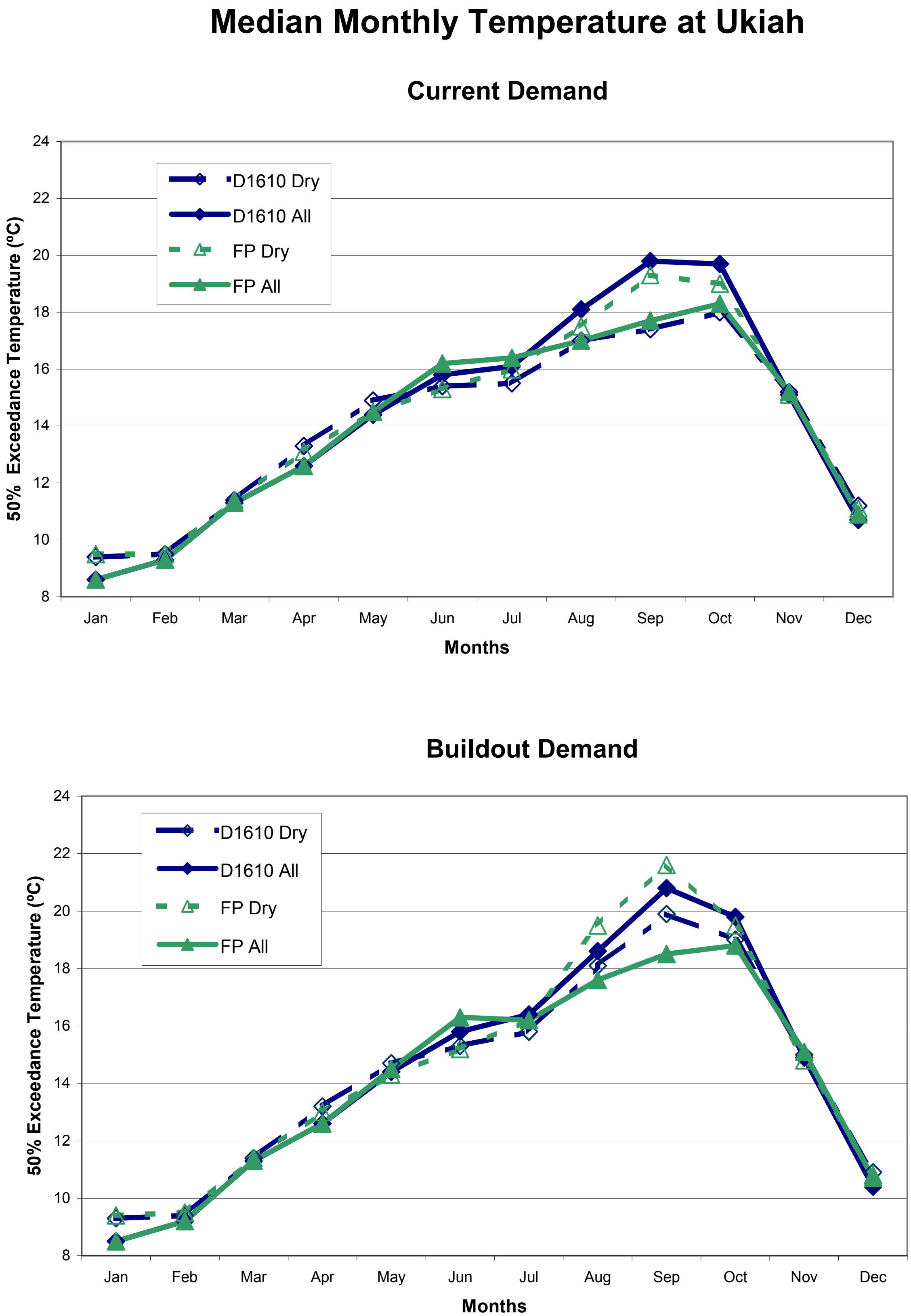


Figure 5-5 Median Monthly Temperatures in the Russian River at Ukiah under D1610 and the Flow Proposal

distance downstream, for both water supply conditions, as observed under the current demand scenario.

During November through May, water temperatures on the mainstem Russian River are similar for the Flow Proposal and D1610 regardless of water supply condition or demand level.

Temperatures in Dry Creek are determined by releases from Warm Springs Dam. These releases are made to meet the needs of DCFH and therefore, are near optimal for salmonids. Near the dam, water temperatures are nearly identical between D1610 and the Flow Proposal under both water supply conditions and both demand levels. Temperature differences occur as the water moves downstream and is subjected to ambient air temperatures. The smaller volume of water released under the Flow Proposal results in water temperatures in the downstream end of Dry Creek that are as much as 1°C warmer than D1610 under *all* water supply conditions and 1.5°C warmer under *dry* water supply conditions, at current demand levels (Figure 5-6). The highest median monthly temperature simulated under the Flow Proposal is 18.9°C. This is well within the appropriate range for rearing steelhead (temperatures up to 20°C are scored as good), but is somewhat stressful for coho salmon. D1610, with a corresponding temperature of 17.9°C, would also receive a score of 2 for coho rearing.

Dry Creek water temperatures between November and April are very similar for D1610 and the Flow Proposal under both *all* and *dry* water supply conditions and both demand scenarios.

5.3.6 Flow-Related Habitat

In the subsequent sections, the Upper Russian River (above Cloverdale) and Dry Creek are discussed more fully than the other reaches because of their importance to salmonid spawning and rearing. Salmon and steelhead use the Russian River downstream of Cloverdale primarily for passage between the ocean and freshwater spawning and rearing habitat. Some spawning by Chinook salmon has been documented further downstream and limited steelhead rearing may occur into the Middle Russian River (Section 2.2.3 and 2.2.4). Flow and water temperatures varies among the reaches and throughout the year. DO is generally favorable for salmonids in all the reaches and very rarely reaches stressful levels. The criteria used to evaluate the effects of flow on all species and lifestages are based on current channel morphology and associated levels of cover, refuge habitat, feeding areas, etc. In the sections that follow, the flows are assumed to vary as described above, but the channel structure is assumed to be constant. The discussion of flow related habitat focuses primarily on the changes in depth and velocity that would occur, and to a lesser extent, on stream width and the proximity of the water to bank structures and vegetation that contribute to overall habitat value.

5.3.7 Coho Salmon

Coho salmon use tributary habitat for rearing and spawning and use the Russian River for passage. The Flow Proposal could affect coho salmon migration in the mainstem Russian

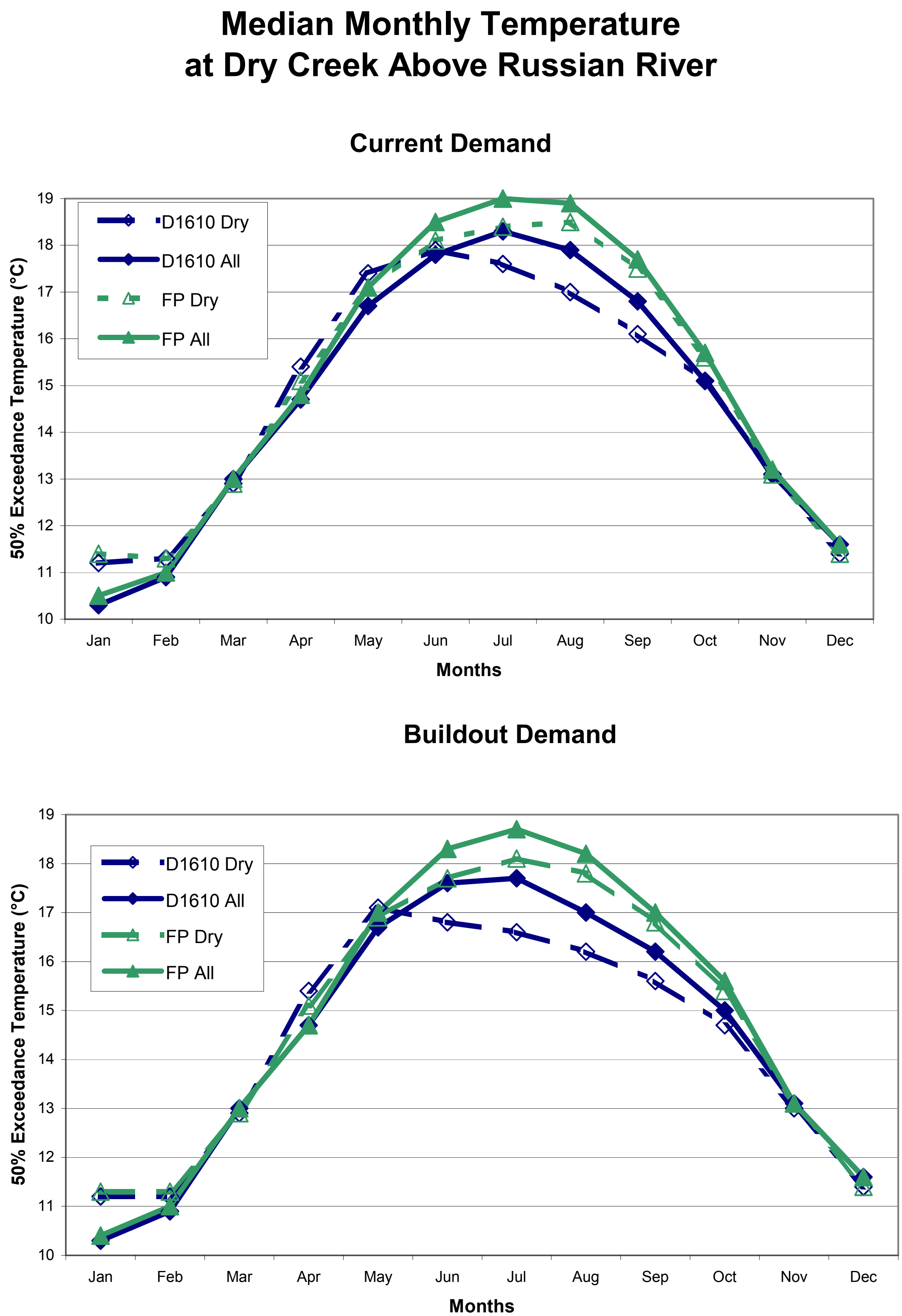


Figure 5-6 Median Monthly Temperatures in Dry Creek above the Russian River under D1610 and the Flow Proposal

River and rearing, migration, and spawning in Dry Creek. The Flow Proposal could change flow-related habitat, water temperatures, and DO. The most important changes would occur to flow and water temperatures. Model results indicate extremely minor changes in DO, none of which would adversely affect coho salmon. The following discussion describes the changes to coho salmon habitat from changes in streamflow and water temperature by river reach.

5.3.7.1 Russian River Flow

Upstream Migration

Coho salmon can migrate upstream in the Russian River at flows of 100 to 2000 cfs (Appendix C). Flows lower than 100 cfs may slow or impede fish migration, and passage may not be possible below 50 cfs. The upstream migration period for coho salmon is November through January. During this period, the Flow Proposal and D1610 would provide similar flows and similar levels of habitat (Figure 5-7).

At Ukiah under the Flow Proposal for *all* water supply conditions, median flows would range from about 170 cfs (November) to 740 cfs (January), and at the Hacienda Bridge from approximately 310 cfs to 2,690 cfs for the same months. Most coho salmon use streams in the Lower Russian River such as Green Valley, Freezeout, and Mark West creeks. Flows in the Lower Russian River from Healdsburg to Hacienda Bridge would provide good migration conditions during most of the migration period.

Under the Flow Proposal, migration flows scored a 3 or greater 73 percent of the time under *all* water supply conditions for both current and future demand levels. Scores less than 3 are due to higher-than-optimal flows throughout the migration period in the Lower Russian River and lower-than-optimal flows in the Upper mainstem during November and December. These scores are almost identical to those assigned to the same locations under D1610. The good passage scores for D1610 indicate that passage conditions are generally suitable when coho salmon are migrating in the mainstem and should be able to reach tributary habitat.

Under *dry* water supply conditions, flows would be lower, ranging from 105 to 169 cfs at Ukiah and from 169 to 767 cfs at the Hacienda Bridge. These flows would provide acceptable passage flows for coho salmon 65 percent of the time (Figure 5-9). Passage may be slowed or impaired 34 percent during *dry* water supply conditions, but flows would not drop low enough to prevent passage. Under D1610, flows for *dry* water supply conditions are similar and provide similar passage opportunities.

For future demand conditions, flows would be slightly higher for both *all* and *dry* water supply conditions, but passage opportunities for coho salmon would stay the same (Figures 5-8 and 5-10).

5.3.7.2 Russian River Water Temperatures

Because coho salmon are migrating in the winter months, water temperatures during the migration period are generally suitable. Water temperatures from 6.0 to 14.0°C provide good-to-excellent conditions for upstream migrants. Under the Flow Proposal under current demand levels, the Lower Russian River at Hacienda and at Healdsburg would have median monthly water temperatures near 14°C in November to 9°C in January. Water temperature scores for the lower river stations would be in the suitable range 91 percent of the time (Figure 5-11). At times, warmer water temperatures have occurred, contributing to scores of 1 or 2 for 9 percent of the time. Low scores are generally due to warmer water temperatures that occur in November in some years. Under D1610 water temperatures are similar to those that would occur under the Flow Proposal.

Under the Flow Proposal for *dry* water supply conditions under current demand level, the water temperatures would remain suitable approximately 90 percent of the time in the areas where coho salmon currently migrate (Figure 5-12). Further upstream, water temperatures warm slightly, but suitable water temperatures would still be available 80 percent of the time.

Under the Flow Proposal, the water temperature during the coho migration period would be similar to those provided under D1610 for both *all* and *dry* water supply conditions at buildout (Figures 5-13 and 5-14).

5.3.7.3 Dry Creek Flow

Juvenile Rearing

The following analysis focuses on flow-related habitat. In general, other coho habitat features are lacking in Dry Creek. Implementation of the Flow Proposal in conjunction with the placement of habitat improvement structures (evaluated in Section 5.5.3.1) is likely to create suitable habitat conditions for coho salmon juvenile rearing.

Juvenile coho salmon rearing conditions in Dry Creek vary with flow. Excellent-to-optimal habitat conditions are present at flows between 45 cfs and 100 cfs. Suitable habitat conditions for juvenile coho salmon span flows from 25 to 120 cfs (Appendix C). The Flow Proposal would provide excellent-to-optimal summer (June through October) rearing conditions throughout Dry Creek. In the reach below Warm Springs Dam, scores of 4 or more would be present 78 percent of the time and 85 percent of the time in the reach above the mouth (Figure 5-15). The lower flows afforded by the Flow Proposal would provide substantially better conditions than D1610 flows.

Under D1610, excellent-to-optimal habitat conditions are provided only 69 and 79 percent of the time in the two reaches (from upstream to downstream) at current demand levels. The Flow Proposal's benefits under future demand for *all* water conditions are even more apparent (Figure 5-16). Under D1610 at buildout demand levels, excellent-to-optimal habitat conditions are provided only 25 and 33 percent of the time in the two reaches (from upstream to downstream). Poor habitat conditions (scores of 2 or less) resulting from high flows and high velocities would occur 56 and 44 percent of the time, respectively.

Flow Proposal flows for *dry* water supply conditions would be similar to *all* water supply conditions for current demand. Summer rearing conditions would be suitable (scores of 3 or greater) 90 to 95 percent of the time throughout Dry Creek (Figure 5-17). Under the Flow Proposal at buildout, higher flows would be released and rearing conditions would decline below Warm Springs Dam. However, excellent-to-optimal rearing conditions would occur 75 to 80 percent of the time, for both *dry* and *all* water supply conditions, respectively (Figures 5-16 and 5-18). These lower scores would result from more frequent high flows. In contrast, under D1610 at buildout demand levels, flows would provide suitable rearing conditions less than 25 to 30 percent of the time under *dry* and *all* water supply conditions.

Given that summer rearing often limits coho salmon production in freshwater streams (Nickelson and Lawson 1998), the Flow Proposal should increase the quality and quantity of coho salmon summer habitat in Dry Creek. This would be beneficial for the recovery of coho salmon stocks in the Russian River.

Upstream Migration

In Dry Creek, flows from 30 to 325 cfs provide suitable conditions for coho salmon migration. Flows below 30 cfs may slow or impede migration, and flows below 10 cfs would likely block migrations (Appendix C). Under the Flow Proposal, flow would provide excellent-to-optimal conditions (scores of 4 or greater) 72 percent of the time below Warm Springs Dam and 68 percent of the time in Lower Dry Creek (Figure 5-15). This would be an improvement in passage conditions below Warm Springs Dam when compared to D1610 flows where scores of 4 or greater only occur 55 percent of the time. About 10 percent of the time passage is impeded or blocked and scores are zero for both water management scenarios. In Lower Dry Creek, flow conditions are similar for both water management scenarios, due to the influence of tributary inflow, which is significant at this time of year. In Lower Dry Creek, conditions tend to be slightly less favorable for upstream migration than at the upstream end of Dry Creek because flows tend to be higher than optimal. Low upstream migration scores in Lower Dry Creek are almost always associated with flows that are higher than optimal.

Similar patterns were evident between the Flow Proposal and D1610 for flows under the buildout demand level as those found for current demand levels (Figure 5-16).

Under *dry* water supply conditions, the Flow Proposal and D1610 would provide similar flows for migrating adults (Figures 5-17 and 5-18). Because flows are higher under *dry* conditions in Dry Creek, passage scores are not as good as under *all* water supply conditions. Scores remain predominantly suitable, with 91 percent of the flows assigned a score of 3, but only 2 percent warranting a score of 4 or more. There were only a small percentage of days (5) where passage scored less than 3.

Overall, the Flow Proposal would provide better upstream migration flow than D1610 for coho salmon in Dry Creek under current and buildout water demands. The largest improvement would occur in the Upper Reach.

Spawning

Flows supporting excellent-to-optimal habitat for spawning coho salmon range from 45 to 100 cfs (Appendix C). Under the Flow Proposal, conditions for coho spawning would improve compared to D1610 for *all* water supply conditions (Figure 5-15). For the reach below Warm Springs Dam, the model predicts that 68 percent of daily flows under the Flow Proposal would receive a score of 4 or greater compared to only 44 percent of the flows under D1610. In Lower Dry Creek, the Flow Proposal and D1610 are similar. The Flow Proposal would provide excellent-to-optimal conditions only 20 percent of the time and poor conditions (scores less than 2) about 40 percent of the time. High flows are usually associated with low scores in this reach.

For buildout demand conditions, the Flow Proposal would provide more spawning habitat in the reach below Warm Springs Dam than D1610. Excellent-to-optimal spawning habitat would be present 70 percent of the time compared to 46 percent of the time under D1610. Spawning conditions in the Lower Reach are similar in both the Flow Proposal and D1610 and have a higher proportion of low scores due to high flows.

Under the Flow Proposal, spawning conditions would improve under *dry* water supply conditions throughout Dry Creek (Figures 5-17 and 5-18). Also under the Flow Proposal, the percentage of flows that are excellent to optimal for coho salmon spawning would increase from 20 to 25 percent relative to D1610 under *all* water supply conditions. Under *dry* water supply conditions and buildout demand levels, the Flow Proposal would provide lower flows than D1610. As shown in Figure 5-18, D1610 provides less favorable spawning conditions under buildout demand than the Flow Proposal in the lower portion of Dry Creek. Very good-to-excellent habitat would be available 45 percent of the time with the Flow Proposal and 33 percent of the time under D1610. Both the Flow Proposal and D1610 are similar below Warm Springs Dam and would provide excellent spawning conditions approximately 90 percent of the time.

Incubation

The Flow Proposal would provide conditions for coho salmon during the incubation period (December 1 to March 30) similar to those available under D1610. Excellent-to-optimal incubation conditions would be present approximately 60 percent of the time for *all* water supply conditions under current demand levels (Figure 5-15). At buildout demand levels there is no real difference between the D1610 and the Flow Proposal throughout Dry Creek (Figure 5-16). Thus, it is unlikely that the Flow Proposal would significantly affect coho incubation relative to D1610.

In Lower Dry Creek under *dry* water supply conditions and current demand levels, the Flow Proposal would produce excellent-to-optimal incubation conditions about 80 percent of the time below Warm Springs Dam, and about 50 percent of the time in Lower Dry Creek. D1610 provides similar conditions (Figure 5-17). The Flow Proposal would produce a few more days (4 percent more) with lower scores in the reach below Warm Springs Dam than D1610 does. This pattern is evident under buildout demand levels as well (Figure 5-18).

Water Temperature

The temperatures for *all* water supply conditions in Dry Creek under the Flow Proposal are generally suitable for all lifestages of coho salmon (Figure 5-19). Daily temperatures would provide excellent-to-optimal habitat conditions over 90 percent of the time (scores of 4 more for all lifestages and reaches) except summer rearing in Lower Dry Creek. Here, higher than optimal temperatures would be stressful for juveniles 90 percent of the time. This occurs for both water management scenarios, although D1610 is expected to provide good rearing temperatures (score of 3 or more) 20 percent of the time. Median daily temperatures during the summer in Lower Dry Creek are generally 17^{o}C to almost 18^{o}C. Water temperatures greater than 16^{o}C are stressful for coho salmon.

Under the Flow Proposal, water temperatures under buildout demand levels would be similar to those under current demands (Figure 5-20). There is a small improvement in water temperatures due to higher flows. This pattern is evident under D1610 as well. Under the buildout demand level, D1610 provides slightly better water temperatures in Lower Dry Creek. *Dry* water supply conditions under current and buildout demand levels show the same patterns. Water temperatures under the Flow Proposal and D1610 would be excellent to optimal in Upper Dry Creek and stressful in Lower Dry Creek (Figures 5-21 and 5-22). D1610 provides slightly better thermal conditions in Lower Dry Creek.

5.3.7.4 Summary

Coho salmon predominately use the mainstem Russian River as a migration corridor. In the Russian River, the Flow Proposal would provide similar conditions for adult migration as D1610. Flows during this time of year are controlled primary by natural runoff and rainstorms. Flows are predicted to provide good to optimal migration conditions about 75 percent of the time for *all* water supply conditions and 65 percent of the time for *dry* water supply conditions, reflecting the lower flows during migration periods. These results are consistent for both current and buildout demand levels. Model results for water temperature indicate that conditions are generally suitable for coho salmon in the Russian River, as daily temperatures were suitable for adult migration over 90 percent of the time.

Coho salmon may use Dry Creek for spawning and rearing. Implementation of the Flow Proposal in Dry Creek would primarily benefit rearing juveniles. As rearing habitat is thought to be the limiting factor for coho salmon in the Russian River watershed, improvements in summer rearing conditions could help coho recolonize Dry Creek and its tributaries. The Flow Proposal would provide good to optimal rearing flows 90 to 95 percent of the time under *all* and *dry* water conditions, while suitable flows under D1610 management occur about 10 percent less often. Under buildout conditions, the Flow Proposal would provide suitable rearing flows much more frequent than D1610, assuring that juvenile coho salmon would continue to survive in Dry Creek as demand levels increased.

The Flow proposal should also improve conditions for upstream migration and spawning in upper Dry Creek and provide similar conditions to D1610 in lower Dry Creek. Both water management scenarios are predicted to provide similar conditions for incubation. Water temperatures are also similar for the Flow Proposal and D1610 and are generally suitable for all life history stages.

5.3.8 STEELHEAD

Steelhead use habitat throughout the Russian River watershed. They use the Lower Reach of the Russian River predominantly as a migration corridor. The Upper and Middle Reaches of the Russian River provide spawning and rearing habitat. Steelhead use many of the tributaries for spawning and rearing, including Dry Creek, and may use the Estuary for rearing as well, when conditions are suitable. The Flow Proposal would change habitat conditions in the Russian River downstream of Coyote Valley Dam to the Estuary and in Dry Creek below Warm Springs Dam to the mouth. The changes that would occur under the Flow Proposal in flow and water temperature and the associated effects on steelhead habitat are discussed below.

5.3.8.1 Russian River Flow

The Flow Proposal would provide flow levels that improve summer rearing flows for steelhead in the Russian River mainstem, relative to baseline conditions. The lower flows provided under the Flow Proposal would provide cooler water temperatures in the Upper Russian River during September and October, with a smaller reduction in August. In the Middle and Lower Reaches of the Russian River, small increases in water temperatures would occur. From November through May, flows in the Russian River would be similar to the D1610 watershed because runoff has a greater influence on the flow patterns than water releases from the reservoirs.

Juvenile Rearing

The Flow Proposal is structured to provide lower flows in the Russian River to improve summer habitat conditions (June through October) for rearing fish. The best rearing habitat in the Russian River is located between Ukiah and Cloverdale. Median summer flows under the Flow Proposal for *all* water supply conditions would range from a high of approximately 180 cfs in June, down to 130 or 140 cfs in October for these locations. Median flows under the Flow Proposal are predicted to be from 45 to 100 cfs lower in the Russian River at Ukiah, Hopland, and Cloverdale compared to D1610 during the summer rearing period (Tables 3-8 and 4-5).

Summer rearing flows under the Flow Proposal would provide lower water velocities in riffles and runs where steelhead juveniles prefer to rear. Daily flow scores for *all* water supply conditions during June through October predict that conditions for rearing would be excellent or optimal 64 to 70 percent of the time depending on location. Cloverdale would have more days scoring 4 or 5 than either Ukiah or Hopland. Under D1610, optimal-to-good rearing conditions are provided only 35 to 40 percent of the time (Figure 5-23). From Ukiah to Cloverdale, the Flow Proposal would provide excellent-to-optimal habitat conditions (scores of 4 or more) for steelhead rearing 58 to 71 percent of the time under buildout demand levels. The higher flows reduce the number of days with optimal scores at Ukiah and Hopland, but Cloverdale scores remain high (Figure 5-24).

During *dry* water supply conditions, median flows would be as much as 30 to 40 cfs higher under the Flow Proposal compared with D1610. Under the Flow Proposal, excellent-to-optimal rearing habitat would be provided 64 to 71 percent of the time, with the highest habitat scores found at Cloverdale (Figure 5-25). Under *dry* water supply conditions, D1610 provides slightly better flow conditions for rearing, with daily flows receiving scores of 4 or greater 10 percent more frequently than the Flow Proposal. Both management scenarios would provide suitable conditions for rearing (scores of 3 or higher) about 90 percent of the time throughout the mainstem, with stressful flow conditions occurring about less than 10 percent of the time.

Under *dry* water supply conditions at buildout (Figure 5-26), scores for the Flow Proposal and D1610 would be better than those for *dry* water supply conditions at current demand levels. D1610 would provide somewhat better conditions than the Flow Proposal.

Upstream Migration

Steelhead migrate up the Russian River mainly during the period January through March depending on storm activity. As described previously, flows are largely governed by uncontrolled runoff from the watershed, rather than the operation of the dams. Flows that provide suitable passage in the Russian River range from 100 to 2000 cfs (Appendix C). Flows are normally in this range during much of the migration period. Higher flows occur more frequently in the lower portion of the river (below Dry Creek and at Hacienda). Under the Flow Proposal under *all* water supply conditions, daily flows during the upstream migration season would range from about 500 to 1400 cfs between Ukiah and Cloverdale, and between 2600 and 3900 cfs at Hacienda Bridge.

Throughout the mainstem, the Flow Proposal would provide good conditions (scores of 3 or greater) for steelhead upstream migration 65 to 75 percent of the time under both current and buildout demand levels, and excellent conditions 25 to 50 percent of the time (Figures 5-23 and 5-24). Flow scores are somewhat lower for the downstream locations, due to accretion that occurs with distance downstream. Flows greater than 2,000 cfs or less than 100 cfs may begin to impair upstream passage for steelhead. These conditions occur about 25 to 30 percent of the time upstream of Cloverdale, and 30 percent of the time at Healdsburg. This impairment is largely due to high flows, although low flows that can impede passage occasionally occur.

Under *dry* water supply conditions, the Flow Proposal and D1610 would provide similar flows during the steelhead upstream migration period. In general, conditions for migrating adults are better under *dry* water supply conditions and improve upstream from Healdsburg. This is due to a reduced frequency of high flows, which results in a greater frequency of scores of 4 or 5. Good habitat conditions for upstream passage are provided about 70 to 75 percent of the time at Ukiah, Hopland, and Healdsburg (Figure 5-25). Slightly improved levels of upstream passage would be available under both water management scenarios at buildout (Figure 5-26).

Spawning

Steelhead spawning occurs from January through April in the Upper Russian River near Ukiah, Hopland, and Cloverdale. In this reach, flows from 100 to 350 cfs provide good habitat conditions for spawning steelhead (Appendix F). During the spawning period releases from the dams have little affect on total flow. About 20 percent of the time in some *dry* water supply conditions, the proposed project operations influence flows in the Russian River in January. Median monthly flows during the spawning period in the Upper Russian River range from 500 to 1400 cfs. Flows at this level are higher than optimal, but continue to provide spawning opportunities in this reach.

Under the Flow Proposal, spawning conditions for *all* water supply conditions at current demand levels are generally ranked low. A large percentage of daily flows are greater than 350 cfs, which receive a score of 2 (Figure 5-23). Excellent-to-optimal conditions would occur 25 to 15 percent of the time, with better habitat conditions predicted for Ukiah. These results are similar to the spawning flows provided by D1610 for the same water supply conditions and demand levels. Spawning conditions under buildout for both water management scenarios were similar to each other and to conditions predicted for current demand levels (Figure 5-24).

Under *dry* water supply conditions, for both current and buildout demand, flow would be lower, providing better spawning conditions under the Flow Proposal and D1610. Good spawning conditions would be present 25 to 40 percent of the time with better conditions found at Ukiah (Figure 5-25). Results are similar for both current and buildout demand levels (Figures 5-25 and 5-26).

Incubation

Flow conditions for incubation are similar under the Flow Proposal and D1610 and as with spawning provide generally unfavorable conditions due to higher-than-optimal flows. Because flows are relatively high during spawning and remain high for most of the incubation period, redd desiccation may occur during the natural recession of flow, but is probably limited to small, localized areas. Redd scour, a more likely effect of flows on redd success, was addressed in Section 5.1.

5.3.8.2 Russian River Temperature

Juvenile Rearing

Juvenile steelhead have a fairly wide tolerance range for water temperatures. Water temperatures from 4 to 20^{o}C provide good-to-optimal habitat conditions (Appendix C). As discussed in Section 5.3.5, under *all* water supply conditions, the Flow Proposal is predicted to produce slightly warmer median monthly water temperatures in the Upper mainstem in June and July and cooler water temperatures in August and October, relative to D1610.

In general, water temperatures are suitable (15 to 20°C) for steelhead rearing in the Upper Russian River (Ukiah, Hopland, and Cloverdale). Water temperatures become less suitable for juvenile rearing with distance below Coyote Valley Dam. Median temperatures at Hopland and Cloverdale are less than 21°C under either demand level, and exceed 20°C in only August and September. These temperatures are considered stressful for steelhead summer rearing, but steelhead can still survive and even flourish if ample food is available. At Healdsburg, median temperatures exceed 22°C from June through September. These temperatures are very stressful, and it is unlikely that growth could be sustained at these temperatures for prolonged periods.

From a comparison of the values in Tables 3-9 and 5-34, median monthly water temperatures in June and July would be slightly higher (less than 1°C) under the Flow Proposal than those provided by D1610 for the same period. The situation is reversed in the August through October period where the Flow Proposal would provide cooler water temperatures than D1610 with differences in median monthly temperatures ranging from 0.4 to 2.1°C.

Under the Flow Proposal the greatest improvement in water temperatures would be evident at Ukiah. The Flow Proposal for *all* water supply conditions would provide excellent-to-optimal thermal conditions 78 percent of the time and poor thermal conditions only 4 percent of the time (Figure 5-27). This represents a gain of 15 percent of days with excellent water temperatures and a reduction of 12 percent of days with poor habitat conditions relative to D1610.

The Flow Proposal under buildout demand levels for *all* water supply conditions would provide similar levels of suitable temperatures as under current demand levels. The differences between the Flow Proposal and D1610 are greater in the late summer period. Water temperatures under D1610 at buildout would be higher, increasing percentage of days when water temperatures are poor (Figure 5-28).

Although under the Flow Proposal for *dry* water supply conditions, the median water temperatures would be slightly higher than those under D1610, they remain in the suitable range for rearing steelhead. The maximum temperature difference between the Flow Proposal and D1610 would be 1.9°C at Ukiah that would occur in September. The difference in water temperatures under the Flow Proposal and D1610 decrease with distance downstream from Coyote Valley Dam toward Hacienda Bridge.

The daily water temperature scores indicate a slightly different perspective than the median monthly temperatures. For *dry* water supply conditions under both current and buildout demand levels, the Flow Proposal would have fewer days at Hopland and Cloverdale where water temperatures were poor (scores of 2 or less) than D1610. At Ukiah, D1610 provides better temperature conditions (Figures 5-29 and 5-30).

Upstream Migration and Spawning

The Flow Proposal would provide suitable water temperatures for upstream migration and spawning throughout the mainstem Russian River. Similar water temperatures are provided by the two water management scenarios regardless of water supply conditions or demand level (Figures 5-27 through 5-30). Most daily temperatures for these lifestages received a score of 4 or greater, with very few days scoring a 2 or less. This is expected, given that flow conditions during these lifestages are largely driven by runoff from unregulated tributary streams.

Incubation

Steelhead embryos incubate in the river gravels from spawning until they emerge as alevins. Steelhead spawn over several months and embryos may be incubating from January through May. Good thermal conditions for steelhead incubation require temperatures of less than 15°C. Temperatures above this cause increasing levels of stress (Appendix C). Water temperatures above 20°C are anticipated to cause substantial mortality.

The Flow Proposal and D1610 would provide similar median temperatures during the incubation period (January through May) under *all* water supply conditions. Most steelhead spawning occurs upstream of Cloverdale. Median monthly water temperatures under *all* water supply conditions range from 8.6 to 14.5°C at Ukiah and from 8.5 to 17°C at Cloverdale. Water temperatures warm with distance downstream from Coyote Valley Dam in March through May, and would reach 17°C at Cloverdale in May and 19°C at Healdsburg.

In *all* water supply conditions, temperatures during the incubation season are generally favorable in the Russian River, with daily water temperatures below 15°C occurring about two-thirds of the time in the downstream locations, and 90 percent of the time in the upstream locations (Figure 5-27). The frequency of stressful temperatures for steelhead incubation increases with distance downstream from Coyote Valley Dam, with poor temperatures (>15°C) occurring about 25 percent of the time from Hopland to Cloverdale. The warm temperatures occur primarily in April and May.

Under the Flow Proposal and D1610, water temperatures during incubation for *all* water supply conditions would be similar regardless of water demand level (Figures 5-27 and 5-28).

In *dry* water supply conditions, temperatures for incubation are slightly less favorable than under *all* water supply conditions. The frequency of stressful scores increases by about 5 to 8 percent from Cloverdale to Ukiah for both the Flow Proposal and D1610.

5.3.8.3 Dry Creek Flow

In Dry Creek, flow conditions are regulated by Warm Springs Dam to a greater degree than the flows on the mainstem Russian River. One of the objectives of the Flow Proposal is to manage Dry Creek to provide better summer rearing conditions while continuing to provide for other life-history activities such as upstream migration and spawning.

Under the Flow Proposal, the median monthly flows during the summer months (June to October) would range from 70 to 55 cfs under *all* water supply conditions, and from about 80 to 65 cfs under *dry* water supply conditions. At buildout, the median flow level would range from 85 to 55 cfs for *all* water supply conditions and from 100 to 60 cfs for *dry* water supply conditions. The magnitude of these flows may be reduced by up to 10 cfs at the downstream end of Dry Creek.

Flows in Dry Creek under the Flow Proposal are predicted to decrease even further relative to D1610 with a reduction in summer flows of 40 to 65 cfs under *all* water supply conditions and 50 to 130 cfs under *dry* water supply conditions.

During *dry* water supply conditions, the D1610 management scenario requires more water to be released from Lake Sonoma to meet demand and to avoid dewatering Lake Mendocino. To maintain suitable salmonid habitat in Dry Creek, the Flow Proposal balances releases from the two reservoirs: decreasing the amount of water released from Lake Sonoma, and increasing releases from Lake Mendocino (hence the higher flows in the Russian River). At buildout, much of the additional water needed to meet demand would come from additional measures, as well as the additional flows in the mainstem, keeping flows at levels to provide good salmonid habitat.

Juvenile Summer Rearing

As discussed in Section 5.3.4, the Flow Proposal would result in reduced flows in Dry Creek relative to D1610 during the summer months. The reduced flows in Dry Creek would provide a substantial benefit to rearing steelhead during the summer months. The *Flow Assessment Study* found that lower flows (around 47 cfs) provided more suitable and optimal habitat for rearing steelhead than did higher flows (90 and 130 cfs). Flows from 14 to 90 cfs provided suitable juvenile rearing habitat conditions in Dry Creek (Appendix C).

For *all* water supply conditions under D1610, flows are near 90 cfs from June through October under current demand, and would be over 90, and up to almost 150 cfs in some months, at buildout. Under the Flow Proposal, these flows would be substantially lower (55 to 85 cfs, and generally less than 75 cfs), increasing the amount of suitable habitat that would be available for juvenile steelhead. As a result, summer rearing scores increase from predominantly 1 and 2 under D1610 to predominantly 4 and 5 under the Flow Proposal for both scenarios (Figure 5-31). Under the Flow Proposal, good-to-optimal habitat conditions would be provided about 90 percent of the time both below Warm Springs Dam and in Lower Dry Creek.

At buildout demand level, the benefits of the Flow Proposal for juvenile steelhead are still evident (Figure 5-32). Excellent-to-optimum habitat conditions would be provided 35 percent of the time at Warm Springs Dam and 55 percent of the time in Lower Dry Creek as compared to less than 1 percent for these two reaches under D1610 at buildout.

In *dry* water supply conditions under current demand, the Flow Proposal would provide habitat conditions similar to those under *all* water supply conditions. Good-to-optimal rearing conditions would be provided 70 and 80 percent of the time below Warm Springs Dam and in Lower Dry Creek, respectively (Figure 5-33). This contrasts with D1610 where excellent-to-optimal rearing conditions are provided only 10 and 20 percent of the time in the same reaches.

At buildout demand levels under *dry* water supply conditions, flows would be increased under both water management scenarios, but to a larger extent under D1610. The flow increases would result in less favorable flow conditions for juvenile steelhead. The Flow Proposal would provide better conditions than D1610. Flows providing good conditions would occur about 65 to 80 percent of the time (Figure 5-34). Under the Flow Proposal the higher flows under *dry* water supply conditions would provide marginal habitat conditions (scores of 1) about 15 percent of the time at Warm Springs Dam and 8 percent of the time in Lower Dry Creek. This is contrasted with marginal habitat conditions that would occur almost 80 percent of the time under D1610 at buildout under *dry* water supply conditions. Under D1610, flows would be greater than 170 cfs from June through September and about 125 cfs in October. This would result in very stressful conditions for juvenile steelhead throughout Dry Creek.

Upstream Migration

Flows of 30 to 325 cfs provide suitable passage conditions for steelhead in Dry Creek. Upstream migration is severely impeded or blocked when flows are less than 10 cfs or greater than 500 cfs (Appendix C).

During the upstream migration period, both water management scenarios provide a similar number of good migration days in Dry Creek. For both current and buildout demand levels, the Flow Proposal and D1610 would provide good migration conditions between 50 and 65 percent of the time, with a higher number of passage days found below Warm Springs Dam (Figures 5-31 and 5-32). The Flow Proposal would provide a higher proportion of days with excellent migration conditions than D1610. This results from an increase in flow under the Flow Proposal relative to D1610 during the adult migration season.

Under *dry* water supply conditions, D1610 would provide slightly better habitat values for upstream migration than the Flow Proposal (Figure 5-33). This occurs because D1610 results in fewer days with flow levels high enough to be considered a barrier to migration (greater than 500 cfs). This would be true for both demand levels (Figure 5-34).

Spawning

Flows in Dry Creek of 30 to 100 cfs provide suitable spawning habitat for steelhead. Spawning conditions are poor at flows higher than 250 cfs and at flows less than 20 cfs (Appendix C).

For *all* water supply conditions under current demand levels, the Flow Proposal and D1610 provide similar conditions for steelhead spawning. Suitable spawning flows would be provided between 50 and 65 percent of the time, with the lower score occurring in Lower Dry Creek for both water management scenarios (Figure 5-31).

For *all* water supply conditions under buildout, D1610 would provide slightly better flows for steelhead spawning than the Flow Proposal. D1610 flows tend to be slightly lower than those under the Flow Proposal and would provide suitable spawning flows about 60 and 40 percent of the time below Warm Springs Dam and in Lower Dry Creek, respectively (Figure 5-32). Under the Flow Proposal, the corresponding conditions would occur about 55 to 36 percent of the time. The frequency of stressful scores would be similar between the two water management scenarios.

For *dry* water supply conditions, the Flow Proposal would provide better overall conditions for spawners, although both water management scenarios would provide very good-to-optimal spawning flows about two-thirds of the time (Figure 5-33). The Flow Proposal is expected to result in good flow conditions about 85 percent of the time near the dam, as compared to about 66 percent of the time under D1610. At the downstream end of Dry Creek, the scores are similar between D1610 and the Flow Proposal. About two-thirds of the flows would provide good conditions and slightly more than half the flows would provide excellent-to-optimal conditions. The results are similar for *dry* water supply conditions under buildout demand level (Figure 5-34).

Incubation

Flows during the steelhead incubation season (January through May) are typically higher for the Flow Proposal than D1610 under *all* water supply conditions by 25 to 75 cfs (Section 5.3.4). Under *dry* water supply conditions, flows are similar between the Flow Proposal and D1610 from January through March, but the Flow Proposal provides higher flows in April and May. The lower flows of D1610 under *all* water supply conditions from January through March, result in better incubation conditions than occur for the Flow Proposal under *all* water supply conditions. At the upstream end of Dry Creek, under D1610, about 55 percent of the time, flows would be between 30 and 150 cfs, providing good flow conditions for incubation. Under the Flow Proposal, good conditions for incubation would be available about 30 percent of the time (Figure 5-31). The Flow Proposal does provide excellent conditions more frequently than D1610, but D1610 would be preferred because of the much greater frequency of good conditions. At the downstream end of Dry Creek, flows would increase due to unregulated local runoff, and conditions for incubation would decline relative to the upstream portion of Dry Creek. Good flow conditions for incubation would be available less than 20 percent of the time under either D1610 or the Flow Proposal. Stressful conditions would occur somewhat more frequently under D1610, but very stressful and potentially lethal flow conditions would occur with about the same frequency under both water management alternatives (Figures 5-31 and 5-32). These results apply to both the current and buildout demand levels.

Under *dry* water supply conditions, flow conditions during the incubation season are similar between the two demand levels in January through March (Figures 5-33 and 5-34). The Flow Proposal results in flows that are about 25 cfs higher than D1610 in April and May. Where flows that are considered stressful occur, they tend to result from flows that are too high. However, for D1610, flows that are too low are more common in April and May. Under *dry* water supply conditions at current demand levels, the flows under

D1610 are lower than optimal. However, these flows still score a 3 approximately 85 percent of the time near the dam. The Flow Proposal's higher flows in April and May shift many of these days from scores of 3 to scores of 5. The same pattern is observed under the buildout demand. In Lower Dry Creek, the two management scenarios result in similar scores. Flows are good for incubation about 40 percent of the time, and would be considered very stressful or potentially lethal about 40 percent of the time. The results for below Warm Springs Dam and Lower Dry Creek apply for both the current and buildout demand levels.

Dry Creek Temperature

Water temperatures in Dry Creek tend to be cool and constant at the upper end below Warm Springs Dam. This is because the release water temperature is carefully managed to meet the needs of DCFH. Water temperatures range from 12 to 13.5°C, which provide excellent-to-optimal conditions for all lifestages. Water temperatures warm somewhat at the downstream end of Dry Creek, but remain within a range that would be considered excellent-to-optimal for most lifestages, most of the time. Water temperatures in Lower Dry Creek are too warm for incubation during the latter part of the season, and rearing temperatures vary between water management and demand scenarios. Water temperature conditions for upstream migration and spawning were similar between the Flow Proposal and D1610 for *all* water supply conditions and demand levels. The following discussion focuses on summer rearing and incubation temperatures.

Summer Rearing

Suitable temperatures for young steelhead range from 4 to 20^{o}C, with optimal temperatures from 12.8 to 15.6^{o}C. Temperatures in this range are always available at Warm Springs Dam. Both the Flow Proposal and D1610 would provide optimal temperatures for young steelhead for *all* water supply conditions and demand levels.

Water temperatures at the lower end of Dry Creek vary with water supply condition and demand level. Because flows are higher, D1610 provides more days with excellent-to-optimal conditions for rearing and suitable temperature conditions occur 100 percent of the time.

For *all* water supply conditions under current demand level, both the Flow Proposal and D1610 would provide nearly the same number of days when water temperatures are suitable (scores 3 or greater) for summer rearing (Figure 5-35). Under the Flow Proposal, the water temperatures in Lower Dry Creek would be in the suitable range 98 percent of the time. At buildout demand levels, water temperatures in Lower Dry Creek would improve under both scenarios. Once again, both scenarios provide suitable rearing conditions nearly 100 percent of the time, with D1610 providing a greater number of days with optimal conditions (Figure 5-36). During *dry* water supply conditions under both current and buildout demand levels (Figures 5-37 and 5-38), water temperatures would be similar to those discussed for *all* water supply conditions with buildout demand level. Both water management scenarios provide suitable water temperatures in Dry

Creek for summer rearing. The lower flows under the Flow Proposal result in slightly lower temperature scores in the lower reach.

Incubation

For incubation below Warm Springs Dam, temperatures would be excellent to optimal about 80 percent of the time. The remaining days would provide good temperatures for incubation. The days with scores of 3 result from temperatures that are too warm, which occur primarily in May. These results apply to both demand scenarios under *all* water supply conditions (Figures 5-35 and 5-36). Under *dry* water supply conditions, temperature scores would again be excellent to optimal near the dam, but the frequency with which temperatures would be only good for incubation would increase to about 33 percent of the time (Figures 5-37 and 5-38). For incubation, water temperatures at the lower end of Dry Creek are good to optimal about 70 percent of the time, but can be very stressful about 10 to 15 percent of the time. These stressful temperatures can occur during April and May, when water temperatures exceed 15°C.

5.3.8.4 Summary

Implementation of the Flow Proposal would benefit steelhead in both the Russian River and Dry Creek. Summer rearing habitat improvements would reap the greatest benefit. Summer rearing conditions would be close to optimal in Upper Russian River more than 64 to 70 percent of the time, compared to only 35 to 40 percent of the time under D1610. Young steelhead would also benefit from the lower water temperatures (0.4 to 2.1°C lower than D1610) in the Upper Russian River in August through October. These benefits in summer rearing conditions would help relieve the summer rearing bottleneck that is currently thought to limit steelhead production in the Russian River watershed and would promote the recovery of this species. The lifestages in the mainstem river during the winter and spring (upstream migration, spawning, and incubation) would experience similar habitat conditions under either water management scenario.

Summer rearing habitat for young steelhead in Dry Creek would improve substantially under the Flow Proposal. Rearing conditions would be excellent to optimal 50 to 75 percent of the time, and good 90 percent of the time. This represents a substantial improvement over the predominantly poor conditions found under D1610 (good conditions occur only 35 percent of the time). The contrast is especially marked for the buildout demand level. Other habitat improvements for spawning and upstream migrations would occur under some water supply and demand conditions. However, incubation would experience less favorable conditions under the Flow Proposal than D1610 because of higher winter flows. During this time of year, flows are largely due to natural runoff from unregulated tributaries and project operations have only a minor influence on flows.

5.3.9 Chinook Salmon

Chinook salmon use the Upper and Middle Russian River as well as large tributaries such as Dry Creek for spawning and rearing habitat. They use the Lower Russian River and the Estuary predominantly as a migration route between the ocean and upstream habitats. The Estuary may also be used for rearing. The Flow Proposal could affect migration, spawning, and rearing in the mainstem Russian River and in Dry Creek. Chinook salmon use the Russian River watershed in the winter and spring when flows are high due to rainfall and runoff from unregulated tributaries. The Flow Proposal has less influence on flow and habitat during this period, particularly in the Russian River. Chinook are generally absent from the system from July through late September or October, when project operations have their largest effect on flows.

Because Chinook salmon are in the watershed during the wetter part of the year, the flows they experience are usually higher than optimal for most species and lifestages. Many of the lifestages, and particularly young fry and juveniles are likely using areas that provide velocity refuge. The success of Chinook salmon may be influenced by the availability of such refuge areas. This is particularly true of Dry Creek, because of its more incised nature and lack of connection with its flood plain.

5.3.9.1 Russian River Flow

Juvenile Rearing

Suitable rearing conditions for juvenile Chinook salmon in the Upper and Middle Russian River are provided by flows ranging from 50 to 275 cfs (based on criteria provided in Appendix C). Flows in the Upper Russian River often exceed these levels during the Chinook rearing period (February through May). These winter and spring flows are largely controlled by runoff from unregulated tributaries and are typically not the result of project operations.

The flows that would occur during the Chinook salmon rearing period under the Flow Proposal are similar to those provided by D1610. As an example, at Cloverdale under *all* water supply conditions, median flows during the February-June rearing period range from 1400 cfs to 180 cfs, respectively (See Section 5.3.5 and Tables 3-8 and 4-5).

In general, under both the Flow Proposal and D1610, flows during the rearing season would be frequently higher than optimal for rearing Chinook salmon. Flows greater than 275 cfs would occur 70 to 80 percent of the time (Tables 3-8 and 4-5). Figure 5-39 presents the evaluation of rearing habitat for Chinook salmon under *all* water supply conditions and current demand levels. The high flows that occur much of the time contribute to marginal habitat conditions in this reach for rearing Chinook salmon. Poor habitat conditions (scores of 2 or less) occurred at Ukiah, Hopland, and Cloverdale 70 to 75 percent of the time. Under these conditions Chinook salmon fry are likely restricted to areas of lower velocity along channel margins and in pools, or may emigrate shortly after emergence. Habitat conditions improve during the latter half of the rearing period when flows are lower. Similar conditions would occur for rearing Chinook salmon under buildout demand levels for both the Flow Proposal and D1610 under *all* water supply conditions (Figure 5-40).

Because flows are lower under *dry* water supply conditions, there is an improvement in rearing conditions compared to *all* water supply conditions. For *dry* water supply conditions, both management scenarios provide good-to-optimal rearing habitat 38 to 45 percent of the time at Ukiah, Hopland, and Cloverdale, while stressful flows (scores ≤ 1) occur only 15 to 32 percent of the time (Figures 5-41 and 5-42, respectively). The overall improvement in habitat conditions is due to a reduction in flow rates between February and April. The Flow Proposal and D1610 provide similar conditions for juvenile rearing under current and buildout demand levels under *dry* water supply conditions.

Upstream Migration

Under current operations (D1610), the Estuary is managed as an open system to prevent local flooding near Jenner. This open system is necessary because of the high flow rates in the lower river during most of the summer. Because of the open system, a few Chinook salmon have entered the Russian River as early as August, although the peak of upstream migration has generally been in October or November (Section 2.2.4).

Under the Flow Proposal, the Estuary would be managed as a closed system. The sandbar at the mouth of the Estuary would remain closed until the rainy season starts, when flows in the river naturally increase, or when the USACE is required to begin releasing additional water out of Lake Mendocino (normally in mid-October), to bring them down to flood control elevation. The habitat conditions for upstream migration presented in this section are for the period from August 15 to January 15 for D1610, based on the current D1610 management scenario with the bar open. The Flow Proposal habitat conditions are evaluated based on a migration season from October 15 to January 15, reflecting the proposed management of the Estuary as a closed system.

Flows that provide good upstream passage conditions for adult Chinook salmon in the mainstem Russian River range from 100 to 2,000 cfs. These flows represent scores of 3 or higher according to the evaluation criteria (Appendix C).

The Flow Proposal and D1610 management scenarios provide similar conditions for upstream migration under *all* water supply conditions. Daily flows are good to optimal for passage about 77 percent of the time near Healdsburg and 87 percent of the time in the Upper Russian River (Ukiah). Flow conditions are expected to be poor for migration about 7 to 10 percent of the time (Figure 5-39). Under buildout demand levels, conditions for upstream migration are also similar for the Flow Proposal and D1610, with about 80 and 87 percent of flows receiving scores of 3 or greater at Healdsburg and Ukiah, respectively (Figure 5-40).

In *dry* water supply conditions, the Flow Proposal provides better upstream migration scores downstream of Cloverdale, because the sandbar at the mouth of the estuary is closed during August and September, when low flows predominate. Under current water demand levels, flows at Healdsburg are good to optimal (scores ≥ 3) about 60 percent of the time for the Flow Proposal compared to 40 percent of the time for D1610. In the Upper Russian River, however, D1610 management is predicted to provide a higher frequency of good migration flows (65 percent vs. 50 percent) (Figure 5-41). Poor flow conditions (scores ≤ 1) occur at about the same frequency for both management scenarios throughout the Russian River. Under buildout demand levels, the Flow Proposal is expected to provide better flows for upstream migration in the lower mainstem relative to D1610, with good-to-optimal flows occurring almost twice as often at Healdsburg. In the upper mainstem, migration conditions are similar under both management scenarios (Figure 5-42).

Spawning

Chinook salmon spawn in the Upper and Middle Reaches of the Russian River from November through January. Suitable spawning conditions are provided at flows ranging from 130 to 400 cfs (scores ≥ 3, Appendix C). Flows in the Russian River often exceed these levels during the Chinook salmon spawning period because flows are controlled mostly by rainfall runoff and not project operations.

The expected median flows are similar under the Flow Proposal and D1610 for both *all* and *dry* water supply conditions under current and buildout demand levels. The current median flows at Ukiah generally increase from November through January, ranging from 170 cfs to greater than 740 cfs, respectively. Flow increases from tributary inflow occur with distance downstream. Corresponding flows in Cloverdale are 190 to 1,080 cfs for the November-January time frame (Table 3-8). Flows under the Flow Proposal are quite similar (Table 4-5), differing by less than 5 percent. Flows from 150 to 300 cfs provide excellent-to-optimal spawning conditions (scores of 4 or 5). Flows are frequently higher than this in the latter portion of the spawning period.

Under *all* water supply conditions with current demand, spawning flows under D1610 are similar to those under the Flow Proposal. Both management scenarios provide good-to-optimal spawning conditions (scores ≥ 3) about 38 percent of the time. Stressful habitat conditions, with daily flow conditions receiving a habitat score of 1 or less, occur between 38 to 45 percent of the time (Figure 5-39). Stressful conditions are generally due to flows being too high (> 400 cfs). As previously discussed, these higher flows are due to natural rainfall and runoff from unregulated tributaries and are not due to project operations. However, a small portion of low scores is due to low flow conditions (less than 100 cfs). Both management scenarios provide similar conditions under current and buildout demand levels (Figures 5-39 and 5-40).

For *dry* water supply conditions under current demand levels, the Flow Proposal and D1610 would provide similar conditions for Chinook spawning (Figure 5-41). *Dry* water supply conditions would provide slightly worse spawning conditions than *all* water supply conditions, with good-to-optimal flows occurring about 24 percent of the time, under both demand levels (Figures 5-41 and 5-42). Poor flows (scores of 1 or less) occurred about 50 to 55 percent of the time, generally because of lower than optimal flows.

Incubation

Median flows during the Chinook salmon incubation period under *all* water conditions are predicted to be similar for the Flow Proposal and D1610 under current and buildout demand levels and for both water supply conditions. Under *all* water conditions, flows during the incubation season are good to optimal (scores of 3 to 5, flows between 130 and 400 cfs) between 33 to 42 percent of the time above Healdsburg and 25 percent of the time at Healdsburg. Marginal-to-poor flow conditions occur about 62 percent of the time (Figures 5-39 and 5-40). In general, flows during the incubation season in the Russian River are high enough (> 400 cfs) to impair incubation, through the potential scouring of redds, especially in the lower mainstem.

Under *dry* water conditions, the Flow Proposal and D1610 again provide similar incubation conditions for current and buildout demand levels (Figures 5-41 and 5-42). About 55 percent of daily flows were good to optimal (score ≥ 3) for incubation in the Upper Russian River (Ukiah). Flow conditions for incubation get somewhat worse downstream from Ukiah, with good-to-optimal flows occurring about 38 percent of the time near Healdsburg. Stressful spawning conditions are due to both high and low flow conditions. Flows that are too low tend to occur more frequently early in the season, while flows that are too high occur more frequently near the end of the incubation season.

5.3.9.2 Russian River Temperature

Juvenile Rearing

Water temperatures are generally very favorable for rearing in the Upper Russian River. Excellent-to-optimal water temperatures for juvenile Chinook salmon rearing range from 8 to 18^{o}C. The Flow Proposal would provide these temperatures in the Upper Russian River between 60 and 95 percent of the time for both current and buildout demand levels (Figures 5-43 and 5-44). The best temperatures would occur at Ukiah. Water temperatures would warm somewhat moving downstream from Coyote Valley Dam. Water temperatures would remain quite good at Cloverdale, with suitable water temperatures (scores of 3 or higher) occurring 90 percent of the time. Poor temperature conditions (scores of 2 or less) would occur only about 10 percent of the time. At Healdsburg, the frequency of poor temperature conditions would increase, and poor conditions would occur about 25 percent of the time, with some potentially lethal conditions (scores less than 1) occurring toward the end of the rearing period. However, even at Hacienda, the furthest downstream station, good-to-optimal temperature conditions would occur about 75 percent of the time.

The Flow Proposal and D1610 would provide similar temperature conditions for both *all* and *dry* water supply conditions and for both current and buildout demand levels (Figures 5-45 and 5-46).

Upstream Migration

Temperatures suitable for upstream migrants range from 5.2^{o}C to 18.4^{o}C for Chinook salmon (Appendix C). The Flow Proposal provides much more suitable temperature conditions than under D1610, with good-to-optimal temperatures being a larger proportion of the available migration period due to the closure of the sandbar at the mouth of the Estuary. This prevents Chinook salmon adults from entering the Russian River when temperatures are too warm. Under *all* water supply conditions, the Flow Proposal would provide temperatures within a suitable range for migration (scores ≥ 3) about 90 percent of the time in the Upper Russian River and 97 percent of the time from the mouth of Dry Creek to the Estuary (Figures 5-43 and 5-44).

For upstream migration, the Flow Proposal provides substantially better temperature scores. This is because Chinook salmon cannot enter the river in August and September when water temperatures are very warm. The frequency of stressful and very stressful temperatures drops from over 40 percent of the time under D1610 to between 2 and 11 percent of the time under the Flow Proposal in the Lower and Upper Russian River, respectively. Under *dry* water supply conditions, the Flow Proposal continues to provide excellent temperature conditions (Figures 5-45 and 5-46).

Spawning

As described in Appendix C, water temperatures suitable for spawning Chinook salmon range from 3.5^{o}C to 15.2^{o}C. Water temperatures for spawning under the Flow Proposal would be similar to those provided by D1610, with flows providing excellent-to-optimal temperature conditions 81 to 90 percent of the time in the Upper and Lower mainstem, respectively. This pattern is consistent under *all* and *dry* water conditions, and for current and future buildout demand levels (Figures 5-43 through 5-46).

Incubation

The temperature range that provides suitable incubation conditions for Chinook salmon incubation is 3^{o}C and 15^{o}C (Appendix C). Water temperatures for incubation under the Flow Proposal would be similar to those provided by D1610, with both scenarios providing excellent-to-optimal temperature conditions about 87 percent of the time. This pattern is consistent under *all* and *dry* water conditions, and for current and full buildout conditions (Figures 5-43 through 5-46).

5.3.9.3 Dry Creek Flow

Juvenile Rearing

Suitable conditions for Chinook salmon rearing in Dry Creek occur at flows ranging from 25 cfs to 110 cfs (Appendix C). Flows often exceed this range in Dry Creek in the spring.

Median rearing flows for Chinook salmon are lower under the Flow Proposal than for D1610 in May and June, but higher in February and March. Under the Flow Proposal, flows between February and June range from 63 to 350 cfs below Warm Spring Dam and

57 to 562 cfs in Lower Dry Creek under *all* water conditions. Corresponding median flows for D1610 range from 95 to 278 cfs below Warm Springs Dam and 87 to 482 cfs in Lower Dry Creek. At buildout demand levels, flows under D1610 would generally be lower in February and March (45 to 120 cfs lower) and about the same in April through June. Flows under the Flow Proposal at buildout demand levels would remain similar to those under the Flow Proposal at current demand levels.

Under *dry* water conditions, median rearing flows would be similar for the Flow Proposal and D1610 at about 75 cfs during January through March. In April and May, D1610 flows would drop to 25 cfs, while the Flow Proposal flows would be about 51 cfs. These flows would be similar for each scenario under current and buildout demand levels.

The Flow Proposal is predicted to provide slightly better rearing conditions for Chinook salmon in Dry Creek relative to D1610, under *all* water supply conditions (Figure 5-47). Daily flows under the Flow Proposal at current demand levels would provide excellent-to-optimal rearing conditions (scores ≥ 4) about 60 percent of the time in Upper Dry Creek and about 43 percent of the time in Lower Dry Creek. D1610 provides corresponding conditions about 6 percent less frequently, although both management scenarios provide a similar frequency of good-to-optimal conditions for rearing. These trends are similar at buildout demand levels (Figure 5-48).

Chinook salmon rearing conditions under *dry* water conditions improve dramatically under the Flow Proposal compared to D1610. Under current and buildout demand levels, daily flows for the Flow Proposal receive scores of 4 or greater about 85 percent of the time below Warm Spring Dam and 55 percent of the time in Lower Dry Creek. These values are approximately twice the frequency with which they occur under D1610 (Figures 5-49 and 5-50).

Upstream Migration

Flows suitable for passage of upstream migrating Chinook salmon in Dry Creek range from 45 to 325 cfs. These flows represent scores of 3 or higher according to the evaluation criteria (Appendix C). The Flow Proposal and D1610 are predicted to provide similar conditions for upstream migration. Under *all* water supply conditions with current demand, adult Chinook salmon are predicted to experience good-to-optimal conditions about 90 to 95 percent of the time in Upper Dry Creek, and 85 percent of the time in Lower Dry Creek (Figure 5-47). The frequency of poor upstream flows (scores of 1) is similar between the Flow Proposal and D1610. Poor conditions are due primarily to lower flows during October. Both management scenarios provide similar conditions for upstream migration under current and buildout demand levels (Figure 5-48).

Under *dry* water supply conditions, D1610 provides slightly better upstream migration conditions than the Flow Proposal for current and buildout demand levels (Figures 5-49 and 5-50). Both management scenarios provide good to optimal flows a large proportion of the time in both Upper and Lower Dry Creek. The slight decrease in Flow Proposal scores relative to D1610 is primarily due to lower flows during October. This flow reduction is intended to improve rearing habitat for juvenile salmonids in Dry Creek (especially coho salmon and steelhead).

Spawning

Chinook salmon spawn throughout Dry Creek. Flows that provide suitable spawning conditions in Dry Creek for Chinook range from 40 to 150 cfs (Appendix C). Flows often exceed these levels during the Chinook spawning period.

Under *all* water supply conditions for current and buildout demand levels, optimal flows (i.e., score = 5) are much more frequent under the Flow Proposal than D1610 (Figures 5-47 and 5-48), although the frequency of scores of 4 or higher is similar between the two scenarios. Daily flows below Warm Springs Dam are predicted to provide very good conditions for spawning, with flows receiving a score of 4 or 5 about 85 percent of the time under both scenarios. In Lower Dry Creek, flows are excellent to optimal for spawning under the Flow Proposal about 58 percent of the time compared to about 55 percent of the time under D1610. Good spawning conditions occur about 63 percent of the time in Lower Dry Creek for both the Flow Proposal and D1610.

Under *dry* water conditions, the predicted frequency of daily flows that receive spawning scores of 4 or greater increases over *all* water supply conditions for both management scenarios (Figures 5-49 and 5-50). In general, flows are good to optimal for spawning 90 to 95 percent of the time throughout Dry Creek. The buildout demand level has little effect on the frequency of daily flows that provide suitable conditions for spawning.

Incubation

The Flow Proposal would provide similar conditions to D1610 for incubation of Chinook salmon embryos under *all* water supply conditions for the current demand level. Both management scenarios provide excellent-to-optimal incubation flows about 70 percent of the time in Upper Dry Creek and 38 percent of the time in Lower Dry Creek. The Flow Proposal, however, yields a much higher frequency of optimal flows (i.e., score = 5) throughout Dry Creek relative to D1610. This pattern is consistent under both current and buildout demand levels. Scores less than 4 are due to higher-than-optimal flows for incubation.

Under *dry* water supply conditions, there is no difference in incubation conditions between the Flow Proposal and D1610. Both management scenarios are predicted to produce better conditions for incubation in *dry* water supply conditions than in *all* water supply conditions, due to a decrease in flow rates. The frequency of excellent-to-optimal flows is again greater in Upper Dry Creek (88 percent) than in the Lower reaches (57 percent) near the confluence with the Russian River. Under buildout demand levels the frequency of flows providing suitable conditions for incubation would be similar.

5.3.9.4 Dry Creek Temperature

Juvenile Rearing

Temperatures are generally highly suitable for Chinook salmon rearing throughout Dry Creek under both the Flow Proposal and D1610 under current conditions (Figure 5-51). In Upper Dry Creek, both management scenarios have excellent temperatures (8 to 17°C) all of the time. In Lower Dry Creek, some warmer temperatures (up to 20°C) are expected under both scenarios, with D1610 resulting in a slightly lower frequency of these warmer temperatures. At buildout, temperature scores improve slightly in Lower Dry Creek for D1610 (Figure 5-52). About 5 percent more days receive a score of 4. Scores remain the same under the Flow Proposal.

Temperature conditions are similar for both *all* and *dry* water supply conditions (Figures 5-53 and 5-54).

Upstream Migration

Under *all* and *dry* water supply conditions, both the Flow Proposal and D1610 provide excellent temperature conditions for upstream migrant Chinook salmon. Scores of 4 or higher are present 84 percent of the time or more, and scores of 3 or higher are present 100 percent of the time. The Flow Proposal provides slightly better conditions in Lower Dry Creek than D1610 under current demand levels. However, at buildout demand, both management scenarios are predicted to provide excellent-to-optimal temperatures throughout Dry Creek almost all the time (Figures 5-51 through 5-54).

Spawning

Both the Flow Proposal and D1610 provide excellent temperature conditions for Chinook salmon spawning under *all* and *dry* water supply conditions. Temperatures are expected to be optimal almost 100 percent of the time throughout Dry Creek for both current and buildout demand levels.

Incubation

Both the Flow Proposal and D1610 also provide excellent temperature conditions for Chinook salmon incubation under *all* and *dry* water supply conditions. Temperatures are expected to be excellent to optimal at least 95 percent of the time throughout Dry Creek for both current and buildout demand levels.

5.3.9.5 Summary

In the Russian River, the Flow Proposal would primarily improve conditions for upstream migration relative to D1610. Under current D1610 operations, the Estuary is managed as an open system to prevent local flooding, which allows Chinook salmon to enter the Russian River as early as August when flow and temperature conditions are not suitable for migrating adults. Under the Flow Proposal, the Estuary would be managed as a closed system, preventing Chinook salmon from entering the Russian River until the sandbar is breached either by rain driven flows or artificially in mid-October, when the USACE begins drawing Lake Mendocino down to flood control levels. The Flow Proposal and D1610 result in similar flow scores for upstream migration during *all* water conditions, in spite of the bar closure. Under *dry* water supply conditions, the Flow Proposal provides a higher frequency of suitable flows for upstream migration. This is especially true for *dry* water supply conditions under buildout demand levels, where the Flow Proposal is predicted to provide good-to-optimal flows almost twice as often as D1610 in the lower and middle Russian River.

Water temperature conditions for adult migration are predicted to improve under the Flow Proposal. By managing the Estuary as a closed system, migrating adults are not exposed to higher water temperatures associated with low flows in August and September. In general, the frequency of stressful and very stressful temperatures declines from over 40 percent under D1610 to about 7 percent under the Flow Proposal.

Both water management scenarios are expected to provide similar conditions for spawning, incubation and rearing. Since fry and juveniles Chinook salmon occupy the Russian River from February through June, flows tend to be higher than optimal for rearing. Conditions are somewhat better for spawning and incubation under the Flow Proposal than D1610 with suitable flows occurring around 40 percent of the time for *all* water supply conditions and 25 to 35 percent of the time for *dry* water supply conditions. Both management scenarios are predicted to provide suitable temperatures for spawning, incubation, and rearing. In general, excellent-to-optimal temperature conditions are expected to occur between 80 to 90 percent of the time during these life history stages.

In Dry Creek, the Flow Proposal would improve rearing conditions for Chinook salmon, especially near Warm Spring Dam under *dry* water conditions. Both management scenarios are expected to provide similar habitat conditions for upstream migration, spawning and rearing, with a high frequency of good to optimal flow conditions. Water temperatures are similar for the Flow Proposal and D1610 for all life history stages and are highly suitable for Chinook salmon throughout Dry Creek.

5.3.10 Estuary Management

The objectives of the proposed Estuary management are to improve habitat for listed fish species and to prevent flooding of local property.

Summertime breaching of sandbars has been found to negatively affect habitat conditions in lagoons (Smith 1990). The Flow Proposal would reduce inflow to the Estuary, which would allow the elimination of artificial breaching of the sandbar during the summer months. Artificial breaching under the Storm-Flow Management proposal may be required to manage storm flow in the spring or fall, and in some dry winters, to prevent flooding of adjacent property.

5.3.10.1 Issues of Concern

In the Russian River, the current Estuary management program implements a program of summertime artificial breaching. The sandbar is breached several times in the summer/early fall, which creates fluctuating DO, temperature, and salinity conditions in the Estuary. Fluctuating salinity and low DO conditions decrease invertebrate populations upon which juvenile salmonids feed (ENTRIX 2002b). Elimination of summertime artificial breaching would improve lagoon habitat conditions for salmonids over baseline conditions by eliminating fluctuating conditions and stabilizing suitable water quality. Coastal lagoon processes that affect salmonid habitat are described in greater detail in the following section.

In addition, the current management plan results in the sandbar being open in the early portion of the migration period for Chinook salmon (late August and September). Thus, adult Chinook salmon can enter the river system before river conditions are suitable for upstream migration. The proposed project seeks to address these issues.

CDFG has expressed concern about the effects of artificial breaching on the Russian River lagoon, which functions as a nursery area for juvenile fish and wetland habitat, primarily in the lower portion of Willow Creek (CDFG 2002). In the *Draft Russian River Basin Fisheries Restoration Plan* (CDFG 2002), CDFG recommends the evaluation of a no-breach alternative as well as lagoon sampling to study conditions for salmonid utilization.

5.3.10.2 Coastal Lagoon Processes during the Low-Flow Season

Estuaries and lagoons provide important rearing habitat for salmonids (Smith 1990; Larson 1987; Anderson 1995, 1998, 1999; Cannata 1998; Reimers 1973; Healy 1982; Levy and Northcote 1982; Kjelson et al. 1982; Simenstad et al. 1982; Anderson and Brown 1982; Meyers and Horton 1982). Steelhead rearing has been documented in many lagoons in Central and Northern California (Smith 1990; Larson 1987; Anderson 1995, 1998, 1999; Cannata 1998). Chinook salmon and coho salmon have also been found rearing in coastal lagoons to the north of the Russian River (Anderson and Brown 1982; Cannata 1998), although it is not clear if coho salmon have extended rearing periods in these lagoons (Anderson and Brown 1982). Steelhead have been caught in the Estuary in the summer during the 5-year monitoring study (MSC 2000).

In California estuaries, inflow is high during the rainy season, then decreases during the dry season. During the summer, a sandbar forms across the river mouth, impounds water, and forms a lagoon. Initially, a saltwater layer is trapped on the lagoon bottom under a freshwater layer. Through natural processes, this saltwater layer becomes warm, water quality initially declines, DO becomes depleted, and anoxic conditions form (Smith 1990; MSC 1997a, 1997b, 1998, 2000; SCWA 2001b). Research conducted in other coastal lagoons indicates that seepage of the saltwater layer through the sandbar, combined with adequate inflow of fresh water from the river, results in a “freshening” of the lagoon, which results in excellent rearing habitat for salmonids. Maintaining stable conditions also benefits the invertebrate foodbase (Smith 1990).

The rate of conversion to a freshwater system depends on the amount of salt water impounded when the sandbar forms. It also depends on the amount of inflow to the system, which contributes to both dilution and to higher water levels that can increase the rate of seepage through the sandbar. High inflows in the spring allow relatively rapid conversion of an impounded lagoon to fresh water. If the sandbar is breached, salt water flows into the lagoon. When the sandbar reforms, salinity stratification occurs, and the cycle of freshening must begin anew. If a sandbar is breached when summer flows are very low, the rate of conversion to a freshwater system can be very slow, resulting in long transition periods, which may not even occur in the remainder of the season (Smith 1990). Therefore, sandbar breaching during the mid to late summer, when inflow is low, is of particular concern.

This process was intensively studied in smaller Central California coast lagoons in Pescadero, San Gregorio, Waddell, and Pomponio creeks. Although these lagoons are small, similar physical processes likely occur in other California lagoons, such as the Russian River Estuary. Smith (1990) found that with the conversion of the system to fresh water, water temperature decreases, DO levels increase, and excellent rearing conditions develop. Despite the shallowness and warm summer water temperatures in these small coastal lagoons, these lagoons are heavily used by steelhead for rearing. Under the Flow Proposal, there would be sufficient inflow to the Estuary to freshen the lagoon once the sandbar closes, and through the physical processes documented in the Smith (1990) studies, suitable habitat for salmonids and their foodbase are likely to develop. Furthermore, shallow water habitat in the lower portion of Willow Creek Marsh may also benefit from stable conditions and provide food resources for salmonids.

Summertime breaching of sandbars, especially during low-flow summer months, has been found to severely alter habitat conditions in lagoons, including water quality and food availability, because salinity stratification results in higher water temperatures and low DO levels, which negatively affect steelhead and their invertebrate foodbase (Smith 1990). Smith (1990) documented poor steelhead growth during periods of warm, stratified water conditions, particularly during long transition periods to freshwater conditions (Smith 1990). In the Navarro River, up to about 5 miles of the river is inundated by a lagoon when a sandbar forms. Many steelhead rear in this estuarine system year-round, particularly Age 1+ and 2+ fish (based on fish-scale analyses for age and early life-history patterns) (Cannata 1998). Closure of the sandbar in the late summer/early fall during the course of a two-year study appeared to result in an upstream movement of steelhead and a temporary reduction in growth rate, but this was followed by an increase in growth rate a short while later with inflow of fresh water from the river (S. Cannata, CDFG, pers. comm. 2000). Steelhead avoided high lagoon water temperatures and low DO levels by residing in the upper water column or moving upstream until the lagoon freshened (Cannata 1998).

Smith (1990) documented that invertebrate populations crashed each time the lagoons went through the transition to fresh water. When the estuaries were open to tidal exchange, saltwater species like crabs and shrimp (*Neomysis* sp.) were abundant. When sandbar formation resulted in anoxic conditions at the substrate in the deeper waters, amphipods were eliminated from those areas. Euryhaline amphipods (*E. O. Gammarus* spp. and *Corophium* spp.) were present throughout the year and their abundance did not appear to depend on salinity conditions. Freshwater insects, especially diving beetles (*Dytisidae*), water boatmen (*Corixidae*), and midge larvae (*Chironomidae*) became abundant in the pondweed after the lagoons converted to fresh water. Continuous breaching, such as occurred at San Gregorio lagoon in the summer of 1986, resulted in low overall invertebrate populations. As salinity stratification was eliminated by freshwater inflow and wind, DO was restored and invertebrate populations recovered (Smith 1990).

Steelhead that rear in food-rich, freshwater lagoons may experience higher growth rates than steelhead that rear in the stream. Smith (1990) analyzed scale samples from adult steelhead and showed that these fish generally comprised a substantial portion of the adult returns (at least 70 percent of a limited sample in Pescadero Creek from 1985 to 1989). McKeon (1985) determined that Estuary-reared juvenile Chinook salmon in Redwood Creek grew to a larger size than river-reared fish, which is likely to improve their chances for ocean survival and return.

The lagoon in Redwood Creek in Humboldt County provides important steelhead and Chinook salmon rearing habitat. This small estuarine system has been significantly modified by flood control levee construction, which has eliminated or degraded much of the estuary as viable rearing habitat (Anderson 1995, Larson 1987). Nevertheless, Anderson and Brown (1982) found that juvenile Chinook salmon do not spend a majority of rearing time in tributary or mainstem habitat in this watershed, confirming the importance of the estuary for rearing. Larson (1987) documented an uncontrolled breach by local landowners in July 1980 that exposed rearing fish to an abrupt transition from fresh to salt water, flushed juveniles to the ocean, eliminated most of the rearing habitat in the lagoon, and probably reduced ocean survival of these fish. Controlled breaching is currently conducted to keep water levels in the Redwood Creek lagoon higher than they would be with uncontrolled breaching, which helps maintain as much rearing habitat in the lagoon as possible (NMFS 1998c; Anderson 1998, 1999).

In summary, coastal lagoons provide important rearing habitat for juvenile salmonids. Summertime artificial breaching of sandbars severely alters habitat conditions in lagoons. If an estuary remains open, good water quality can be maintained with tidal mixing or high river flows. In a lagoon (sandbar-closed), good water quality develops when the system is converted to fresh water, and stable habitat conditions form. Infrequent breaching, especially during low-flow summer months, impairs water quality because salinity stratification repeatedly results in periods of higher water temperatures and low DO levels. Fluctuations in temperature, DO and salinity affect salmonid habitat, primary production, and the abundance of aquatic invertebrates upon which young salmonids feed. The frequency of breaching and the amount of freshwater inflow are two major factors that influence water quality in a lagoon or estuary system.

Given the importance of other estuarine systems for juvenile salmonid rearing and the limited amount of juvenile rearing habitat in the Lower Russian River mainstem (see Section 2.1.5), the proposed project represents an important opportunity to improve summer rearing habitat in the watershed in a highly productive estuarine environment. The upper portion of the Estuary may be important for juvenile rearing, especially since a coastal fog belt moderates high river water temperature in the summer. Chinook salmon that migrate down the Russian River in the spring may rear for some time in the food-rich

Estuary. The tributaries in the lower Russian River contain high quality steelhead spawning and rearing habitat, and therefore steelhead have easy access to estuarine rearing habitat. Under the proposed Low-Flow Estuary Management program, the lagoon would provide good summer water quality and an increased food supply, which would result in good growth rates for listed fish species and increased chances for their ocean survival. Summer rearing habitat may be a limiting factor for salmonids in the Russian River watershed and therefore the proposed Estuary management provides an important opportunity provide additional, high-quality, oversummering habitat.

5.3.10.3 Potential Effects of Artificial Breaching

The Low-Flow and Storm-Flow Management proposals have the potential to affect salmonid rearing habitat and migration. When the sandbar forms, water quality degrades in the short-term. However, by eliminating summertime artificial breaching, fluctuating conditions would be eliminated, and long-term (throughout the summer) improvements to water quality in the Estuary would be realized. This can directly affect salmonid habitat, primary productivity, and the availability of aquatic invertebrates upon which young salmonids feed. Artificial breaching can, in combination with flow dilution, reduce the concentration of nutrients and toxic runoff from the watershed by opening the Estuary to tidal flushing. With elimination of summer breaching, water-quality conditions in the lagoon would change.

The proposed Estuary management would also affect fish passage during both downstream and upstream migrations. Adult Chinook salmon congregate at the mouth of the river as early as late-August, and if artificial breaching is no longer conducted during this time, early migrants would be prevented from entering the river prematurely. Under the Storm-Flow Management program, the sandbar would be breached close to the time it would naturally breach, and migrants would remain in the ocean until rising river flow improves river conditions. Sandbar breaching activities have the potential to flush juvenile salmonids out of the lower Estuary before they are ready. Finally, artificial breaching of the sandbar has the potential to increase the risk of predation on listed fish species by concentrating fish or increasing incidental bycatch from angling. The issues evaluated are summarized as follows:

- Effects on water quality
- Effects on juvenile rearing habitat
- Opportunity for premature adult upstream migration
- Effects on juvenile downstream migration
- Changes in risk of predation
- Changes in incidental angling pressure or poaching

Potential effects are evaluated for the sandbar-closed management scenario under the Low-Flow Estuary Management proposal. Effects of artificial breaching for Storm-Flow Management are also assessed.

5.3.10.4 Low-Flow Estuary Management/Sandbar-Closed

Water Quality

The Russian River flow would be managed so that once the sandbar closed, freshwater inflow would be sufficient to freshen the lagoon. Flow would be reduced over the summer, following the natural flow in Austin or Maacama creeks, but it would not be reduced below a minimum floor of 35 cfs at the Hacienda gage. The lagoon water surface elevation, measured at the Jenner gage, would be approximately 7 feet when the sandbar first closes, but could be expected to vary from 8 feet in the early summer to approximately 6.0 feet later in the summer.

The preliminary estimate of flow at which the sandbar is predicted to close is 90 cfs at Hacienda, although sandbar closure would vary depending on ocean conditions near the river mouth. Modeled median flows at Hacienda are listed in Table 5-35. Based on the 90 cfs estimate, the sandbar would be predicted to close in June or July, although in *critically dry* years it may close earlier. Except in *critically dry* years, modeled median flow during the summer months ranges from 52 to 78 cfs. In *critically dry* years, flow may drop to the minimum floor of 35 cfs. These flows would provide sufficient inflow to freshen the lagoon. The sandbar would not be breached during the summer and the lagoon would remain closed until the onset of the rainy season. This would provide suitable water quality throughout the summer months. Higher inflow to the lagoon in October, as well as releases from the flood control storage pools of Lake Sonoma and Lake Mendocino in October, would likely result in a return to open sandbar conditions.

Table 5-35 Predicted Median Flow (50 percent Exceedance) near Hacienda Bridge (RM 20.8) under the Flow Proposal under Current Demand

Water Supply Condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Critical	121	68	41	41	35	38	40	460
Dry	596	327	123	52	65	71	57	169
Normal	1795	672	175	75	67	77	106	302
All	1795	672	188	78	68	78	119	313

Monitoring over a 5-year period has found that each time the sandbar closes, water temperatures increase, DO levels decline, and anoxic conditions form in near-bottom layers (MSC 1997a, 1997b, 1998, 2000; SCWA 2001b). Under the Low-Flow Estuary Management proposal, freshwater inflow would force the salt water out of most of the lagoon, which would restore and stabilize DO levels and water temperatures in the lagoon. With elimination of summertime breaching, the repeated occurrence of poor water-quality events and fluctuating conditions would be eliminated. This is likely to improve summer and fall habitat conditions for salmonids and their invertebrate foodbase over D1610 conditions. The fish species and life-history stage that would most likely benefit is steelhead rearing. Coho salmon may use the lagoon for summer rearing. Both species may utilize the lagoon for rearing because of proximity to spawning and rearing streams in the lower watershed. Chinook salmon migrate out of the system by the end of June, and therefore are less likely to utilize the lagoon for rearing.

When the Flow Proposal is implemented, *dry* season flows reduced, and the sandbar remains closed, dilution of nutrients, and point and nonpoint sources of pollution to the lagoon from agricultural and urban runoff would be reduced (see Section 2.1.2.5). Toxic substances have rarely been detected in Russian River monitoring programs (NCRWQCB 2002a), and therefore are not likely to be an issue in the Estuary. A TMDL for ammonia and DO has been completed for the Laguna de Santa Rosa, the only waterbody in the watershed listed under the CWA 303 (d) list for impairment for nutrients, and implementation is underway to reduce and/or eliminate nutrient sources. No reaches of the mainstem have been listed as impaired for nutrients. Recent additions to the CWA Section 303(d) list include the Russian River Guerneville HSA for pathogens because the river sometimes exceeds water-quality objectives for fecal coliforms near Healdsburg Memorial Beach and Monte Rio Beach in the summer (NCRWQCB 2001b). Treated sewage is not discharged in the watershed during the summer months (SCWA 1998a). Nonpoint-source discharges from failing septic systems along the Russian River have not been fully identified.

With the elimination of tidal flushing and reduction of flows in the lower river, dilution of pollutants may be reduced. Although dilution of pathogen loading to the lagoon may be lower than under baseline conditions, there are no data that indicate fecal coliform levels are high, aside from the two summer beach locations noted above (Healdsburg Memorial and Monte Rio beaches). Therefore, this may not have negative effects on salmonids.

Juvenile Rearing

Implementation of the Low-Flow Estuary Management proposal would improve rearing habitat over baseline conditions by stabilizing water quality, water levels, and shoreline vegetation, and by improving the invertebrate foodbase. Steelhead currently utilize the Estuary for rearing, and therefore are most likely to benefit from improved summer rearing habitat. Primary coho salmon rearing habitat is found in tributaries rather than in the Estuary, and therefore may not realize substantial benefits, but coho salmon may also utilize the lagoon. Chinook salmon juveniles may rear for a period of time in the Estuary, but in most years would likely emigrate before the sandbar closes.

As discussed previously, rapid or fluctuating changes in salinity and water quality can have substantial effects on the invertebrate foodbase. The proposed action would allow a freshwater-dominated system to develop, stabilizing water quality during periods when the lagoon is closed, thereby improving rearing habitat conditions. Balancing rates of inflow with natural seepage through the sandbar, losses from evaporation, and tidal influences would allow maintenance of suitable habitat quality.

The Flow Proposal could increase water temperature of summer inflow to the lagoon. High summer water temperatures naturally occur in the lower Russian River. However, coastal influences in the Estuary and lower mainstem tend to reduce summer water temperatures. While water temperatures in the mainstem downstream of the Mirabel facilities may increase under the Flow Proposal or during *dry* and *critically dry* water years, a reduction in warmwater inflow to the Estuary may help offset temperature effects in the lagoon.

Overall, the proposed management program is likely to result in a more stable ecosystem that would improve summer rearing habitat over conditions under D1610. Stable conditions would result in better water-quality conditions, improve primary productivity and the invertebrate foodbase, and stabilize marsh and shoreline vegetation.

Juvenile Outmigration

Juvenile coho salmon, steelhead, and Chinook salmon pass through the Estuary during their outmigration period. Steelhead smolts caught during the 5-year monitoring study were very fit and plump, suggesting they may be feeding while in the Estuary (MSC 2000).

Under baseline conditions, most sandbar closures occur in the late summer and early fall. Under the Flow Proposal, the sandbar may close in the spring or early summer in some years, depending on inflow to the lagoon and ocean conditions. Without artificial breaching, downstream migrants may not be able to emigrate until fall. The end of the Chinook salmon downstream migration period occurs in June, and under the Low-Flow Estuary Management program, the sandbar may close in June in some years. Peak Chinook salmon downstream migration occurs earlier in the spring, but juvenile fish at the end of the season may be trapped in the lagoon for the summer. However, inflow to the Estuary would be reduced after primary downstream migration periods for all three species, and therefore, potential effects on juvenile outmigration are likely minimal. Effects are most likely to occur during *critically dry* years when low flows may result in spring sandbar closures. As habitat conditions in the lagoon improve, juvenile fish would benefit from additional rearing time in the food-rich environment that develops.

Predation

Artificial breaching creates a passageway that could potentially concentrate juvenile or adult salmonids. This may affect the level of pinniped or avian predation. By eliminating artificial breaching during the summer, the risk of predation would be reduced.

5.3.10.5 Storm-Flow Estuary Management

The biological effects of artificial breaching events during the rainy season are evaluated for early-season and late-season breaches.

Early-Season Breach Events

Early-season artificial breach events are defined as breaches that occur at the onset of the rainy season (see Section 4.3.3). Sandbar breaching has the potential to flush juvenile salmonids out of the Estuary before they are ready to go.

One of the protocols that can minimize effects to salmonids in the lagoon during the fall/winter season is to implement artificial breaching as close as possible to the time when a natural breach might occur. Early season breaches would only be conducted if runoff from a rainfall event is likely to result in a WSE greater than a target of 8 feet, to avoid flooding of local properties that would occur at WSE greater than 10 feet. Therefore, timing of artificial breaches would occur as closely as possible to naturally occurring breaching events.

Data are not available to determine at what WSE the sandbar would likely breach naturally, and it would vary depending on flow and ocean conditions as well. However, by timing artificial breaching to the onset of winter rains and delaying breaching activities as late as possible, the breaching program will approximate the natural breaching schedule to the fullest extent possible while maintaining flood protection to surrounding properties. Once the sandbar is breached, tidal flushing would create salinity gradients within the Estuary for juvenile salmonid acclimation before emigration. Juvenile fish that have not been acclimated to salt water would be able to move to fresher surface waters or move upstream. Some steelhead that rear in the lagoon for the summer, or late Chinook salmon migrants that may have been trapped when the sandbar closed, would emigrate in the fall.

SCWA staff's observations during artificial breaching events suggest that, while water velocity within the breach channel is very high, velocity in the Estuary is not (S. White, SCWA, pers. comm. 2000). A hydraulic head between low tide and gage heights up to 7.5 feet creates a rush of water when the berm is first breached. The trench is about 10 feet wide and a couple of feet deep when first dug, but by the time the water has slowed the channel can be 100 feet wide. However, water velocities in the Estuary appear to be nondetectable. Gulls have been observed floating on the water 50 to 100 feet from the breach. Seals swim within 20 feet of the wash, avoiding the channel. These observations suggest that the risk of juveniles being flushed out during a breaching activity is low.

In the past, local residents have conducted unauthorized breaching. They are likely to do so in the future if threats to local property occur, which could result in infrequent summertime breaching that could negatively affect salmonid habitat. By generally keeping the WSE at approximately 7 feet or less during the dry season, the probability of such illegal breaching events would be reduced.

Late-Season Breach Events

Late-season breach events are events that occur near the end or after the end of the rainy season. Because water-quality conditions in the lagoon during summer appear to be an important factor for steelhead rearing in the lagoon, late-season breaches are examined for possible impacts on water quality. Factors that most likely influence water-quality conditions during the summer include:

- The amount of salt water in the lagoon when the sandbar forms and closes the lagoon.

- The amount of freshwater inflow immediately following lagoon closure and the amount of inflow during subsequent weeks.

- The rate of water loss from the lagoon through sandbar seepage, evaporation, and evapotranspiration (loss of salt water through the bottom layer, and fresh water from surface layer).

Late-season breaching is of particular concern if it occurs when summer flow is reduced. Under these conditions, freshwater inflow may be expected to convert the water in the lagoon from salt water to fresh water at a slower rate, and if flow were low enough or the breach were late enough in the season, the lagoon may not freshen at all.

Under the Flow Proposal, the Russian River would be managed so that sufficient river flow is available to freshen the lagoon relatively quickly and early in the season so that good water-quality conditions could be stabilized throughout the summer.

Water Quality near Willow Creek

A fish kill was documented in 1992 when breaching occurred at WSE levels of over 9 feet and a flush of anoxic water drained out of Willow Creek into the Estuary (RREITF 1994). The current Estuary Management Plan breaches the sandbar between 4.5 and 7 feet and prior to storm events. Fish kills due to poor water quality have not been documented under baseline conditions.

Although the cause of this anoxic water is not known, there are a couple of factors to consider. One is that when the WSE begins to rise after the sandbar is closed, terrestrial vegetation is submerged, dies, and contributes to biological oxygen demand, degrading water quality in the marsh in Willow Creek. Another factor is the mobilization of anoxic bottom layers in Willow Creek when the sandbar was breached at WSE levels above 9 feet.

This would likely be avoided under the proposed project because artificial breaching would generally occur at WSE levels below 8 feet and when the river stage is rising. Because sandbar breaching would be delayed until a rainfall event results in increasing stage elevations, potential flushes of poor quality water from Willow Creek would be diluted, thereby reducing the risk. Furthermore, if the WSE in a lagoon is maintained at a stable level, aquatic vegetation would become established, contributing to higher DO levels in lower Willow Creek Marsh or shallow water habitats at other tributaries. In this case, water quality could improve in the marsh.

Juvenile and Adult Migration

Artificial breaching has the potential to cause juvenile salmonids to be swept out of the Estuary before they are physiologically ready to migrate to the sea. Steelhead that rear in the Estuary during the summer, as well as late Chinook salmon migrants, may need some time to acclimate to salt water before emigrating to the ocean in the fall. As discussed earlier, by concentrating artificial breaching to a time when it would naturally occur at the onset of winter rains, this risk would not be substantially higher than occurs under natural breaching events. SCWA staff observations during past artificial breaching events suggest that the risk of juveniles being flushed out during a breaching activity is low. When salinity gradients have formed in the Estuary, juvenile fish would be able to move to fresher surface waters or move upstream.

Upstream migration periods for adult coho salmon and steelhead occur much later in the year than for Chinook salmon, so artificial breaching would most likely affect adult Chinook salmon migration. Although peak migration for Chinook salmon occurs in October to November, adult Chinook salmon have been documented at the Mirabel inflatable dam as early as late-August. A key consideration is whether passage conditions in the river are suitable when the sandbar is breached.

Under baseline conditions, artificial breaching provides earlier passage opportunities for adult Chinook salmon and early migrants may enter the river prematurely, when flow is low and water temperature high. Under the proposed project, the sandbar would be breached as close as possible to when a natural breach is likely to occur, when the river stage is rising and passage conditions in the river are more suitable.

Predation and Changes in Angling Pressures or Poaching

Currently, there are large self-sustaining populations of harbor seals, and occasionally California sea lions and elephant seals appear in low numbers. Their peak populations tend to occur in the late winter and mid-summer (MSC 2000), which coincides with adult and smolt migration periods. Pinniped predation is a natural occurrence during these times. The sandbar would be artificially breached for storm-flow management as close as possible to a time when it would naturally breach, and therefore, it is not likely to substantially increase the risk over natural conditions.

Artificial breaching may potentially increase incidental angling pressure or poaching opportunities on adult salmonids, particularly Chinook salmon. An artificial breach in August or September may produce a freshwater outflow that attracts Chinook salmon into the river prematurely. If the fish are trapped in areas of low-flow or high water temperatures that stress them, they may be more likely to be caught. When artificial breaching is delayed to a time when rainstorms are likely to result in rising river stage the risk of angling pressure or poaching to adult Chinook salmon is lower than D1610 conditions.

Figure 5-7 Upper Russian River Coho Flow Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-8 Upper Russian River Coho Flow Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-9 Upper Russian River Coho Flow Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-10 Upper Russian River Coho Flow Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-11 Russian River Coho Temperature Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-12 Russian River Coho Temperature Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-13 Russian River Coho Temperature Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-14 Russian River Coho Temperature Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-15 Dry Creek Coho Flow Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-16 Dry Creek Coho Flow Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-17 Dry Creek Coho Flow Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-18 Dry Creek Coho Flow Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-19 Dry Creek Coho Temperature Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-20 Dry Creek Coho Temperature Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-21 Dry Creek Coho Temperature Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-22 Dry Creek Coho Temperature Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-23 Russian River Steelhead Flow Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-24 Russian River Steelhead Flow Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-25 Russian River Steelhead Flow Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-26 Russian River Steelhead Flow Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-27 Russian River Steelhead Temperature Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-28 Russian River Steelhead Temperature Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-29 Russian River Steelhead Temperature Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-30 Russian River Steelhead Temperature Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-31 Dry Creek Steelhead Flow Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-32 Dry Creek Steelhead Flow Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-33 Dry Creek Steelhead Flow Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-34 Dry Creek Steelhead Flow Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-35 Dry Creek Steelhead Temperature Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-36 Dry Creek Steelhead Temperature Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-37 Dry Creek Steelhead Temperature Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-38 Dry Creek Steelhead Temperature Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-39 Upper Russian River Chinook Salmon Flow Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-40 Upper Russian River Chinook Salmon Flow Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-41 Upper Russian River Chinook Salmon Flow Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-42 Upper Russian River Chinook Salmon Flow Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-43 Russian River Chinook Salmon Temperature Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-44 Russian River Chinook Salmon Temperature Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-45 Russian River Chinook Salmon Temperature Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-46 Russian River Chinook Salmon Temperature Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-47 Dry Creek Chinook Salmon Flow Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-48 Dry Creek Chinook Salmon Flow Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-49 Dry Creek Chinook Salmon Flow Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-50 Dry Creek Chinook Salmon Flow Scores for Dry Water Supply Conditions at Buildout Demand Levels

Figure 5-51 Dry Creek Chinook Salmon Temperature Scores for All Water Supply Conditions at Current Demand Levels

Figure 5-52 Dry Creek Chinook Salmon Temperature Scores for All Water Supply Conditions at Buildout Demand Levels

Figure 5-53 Dry Creek Chinook Salmon Temperature Scores for Dry Water Supply Conditions at Current Demand Levels

Figure 5-54 Dry Creek Chinook Salmon Temperature Scores for Dry Water Supply Conditions at Buildout Demand Levels

5.4 Channel Maintenance

The effects of the following four general channel maintenance activities on listed fish species in the Russian River watershed were evaluated and are presented below.

- Sediment maintenance
- Debris clearing
- Vegetation maintenance
- Bank stabilization

Effects of operation and maintenance of flood control reservoirs were also evaluated. Channel maintenance in the Russian River mainstem and Dry Creek was evaluated for activities related to construction and operation of Coyote Valley and Warm Springs dams and for specific federal and nonfederal (Public Law 84-99) sites.

SCWA would continue to perform channel maintenance in the Russian River and its tributaries in Sonoma County, and MCRRFCD would continue to perform channel maintenance in the Russian River in Mendocino County.

5.4.1 Issues of Concern

Channel maintenance and NPDES permit activities may have direct and indirect effects on listed fish species and their habitat. There may be both immediate, direct effects of channel maintenance activities during implementation, and effects that may persist after a maintenance activity has been completed as a result of channel geomorphic or fish habitat alteration. For example, riprap installation for bank stability control may have immediate effects related to equipment working in a channel with water. After installation, the riprap may have effects on the amount of cover, water temperature, or other habitat conditions that persist over time.

Issues of concern include:

- Immediate, direct effects from construction and operation and maintenance activities:
  - Increased fine sediment and turbidity.
  - Injury to listed fish species due to equipment operation.
  - Direct mortality or injury to listed species due to chemical release for vegetation control.
  - Entrapment or injury of listed fish species at flood control reservoirs.
- Alterations to habitat from:
  - Streambank and streambed stabilization
  - Sediment maintenance
  - Debris clearing

- Vegetation control
- Passive operation of flood control reservoirs

- Indirect effects from NPDES stormwater discharge permit activities

SCWA would conduct channel maintenance activities for flood control on more than 300 miles of streams within Sonoma County, most of which are located in the Russian River watershed (Central Sonoma Watershed Project and Mark West Creek watershed, Rohnert Park, Cotati, and Sebastopol channels).

Gravel-bar grading and vegetation removal related to bank stabilization in the Russian River would be conducted under different protocols to minimize injury to fish or sedimentation in habitat. These activities were evaluated. Emergency bank stabilization work conducted in natural waterways, including the Russian River, is also discussed in this section.

Activities and protocols related to gravel-bar grading in the Russian River to increase infiltration to the aquifer beneath the river evaluated in Section 5.4.5. These activities differ slightly from gravel-bar grading activities for flood control purposes evaluated in Section 5.4.2. Finally, indirect effects from NPDES stormwater discharge permit activities were also evaluated.

5.4.2 CENTRAL SONOMA WATERSHED PROJECT AND MARK WEST CREEK WATERSHED

Under the proposed project, channel maintenance activities would continue to be conducted on specific constructed flood control channels and natural waterways (see Tables 3-12 and 3-14). Some of the natural waterways were straightened, shaped, and stabilized between 1958 and 1983. Routine sediment removal would not be performed in these natural waterways, except in response to an emergency event (see Section 5.4.4). Operation and maintenance of flood control reservoirs were also evaluated for effects on listed fish species.

5.4.2.1 Sediment Maintenance and Channel Debris Clearing in Constructed Flood Control Channels

SCWA is responsible for sediment maintenance activities in constructed flood control channels to maintain channel flow capacity. Under the proposed project, SCWA would conduct sediment removal as-needed in constructed flood control channels. Although sediment deposits occur to some degree in many of the flood control channels, sediment maintenance work would be needed primarily in channels located in the Rohnert Park-Cotati area.

Sediment removal from constructed flood control channels would be performed when field inspections indicate that the invert elevation of outfall channels is generally less than 12 inches above the streambed. Sediment removal would be performed during the summer or fall months (until October 31) when most flood control channels are dry. However, in some years sediment removal activities may occur in channels with isolated, standing pools or with small amounts of flowing water that are, in part, derived from urban return flows (such as water from lawns). Because sediment removal activities take place during the summer and fall, the life-history stages that potentially could be directly affected are rearing juvenile steelhead or coho salmon.

Limited and Poor-Quality Habitat

Salmonid rearing habitat in most of the constructed flood control channels is very limited and is of marginal quality where it does exist. Therefore, flood control channels may serve primarily as migration corridors to and from upstream spawning and rearing habitat. Good-quality habitat is located in the Mark West Creek watershed, so fish passage in constructed channels in that watershed is especially important. Flood control channels in the Rohnert Park-Cotati area have very limited and poor-quality rearing habitat due to:

- Very low to dry summer flow conditions
- Poor water quality due to urban runoff
- Straightened channel
- Low-channel gradients
- Susceptibility to sediment deposition

Juvenile rearing habitat is mostly unavailable in streams draining the Rohnert Park-Cotati area because many of these channels are often naturally dry, or have very low flows during the summer. Dry or very low summer flows were most likely the predominant historical condition that existed in these channels. Pool/riffle type habitat that is necessary for successful salmonid rearing is poorly developed due to the straightened channel. Channel straightening, which is an integral part of the flood control design, eliminates natural channel sinuosity (i.e., meandering). Sinuosity is an important element of the natural channel geomorphology that promotes pool development on outside bends of meanders, and bar development on the inside of the meander. Because the flood control channels are permanently straightened, the formation of pool-bar units within a meandering channel is inhibited. This lack of corner pools and bars limits the availability of rearing habitat.

Sediment deposits occur to some degree in many of the SCWA flood control channels. Deposition negatively affects flood capacity and requires excavation most frequently in those channels that have a relatively low gradient such as flood control channels in the Rohnert Park-Cotati area (see Figure 3-6). The average flood control channel gradient is approximately 0.2 percent. In channels that tend to require excavation in the Rohnert Park-Cotati area, gradients are often even lower than 0.2 percent. Sediment deposition reduces the depth and capacity of pools (if they are present), thereby limiting the quality and availability of rearing habitat. In combination, the lack of summer flows and limited amount and depth of pool habitat is likely to cause high summer water temperatures to occur in the flood control channels. Large diurnal temperature fluctuations that also limit the quality of juvenile rearing habitat can also occur.

For all of the reasons presented above, rearing habitat is likely to be extremely limited or not present in those Rohnert Park-area flood control channels that require sediment removal to maintain flood capacity. A few salmonids may rear in these channels during the summer months, but the primary function of these channels would be as a migration corridor. Steelhead are the most abundant of the listed species present in these channels. Coho salmon and Chinook salmon may also use portions of these channels, but are unlikely to be either widely distributed or to be a significant presence (see Section 2.2.4). Due to the limited presence of salmonids in the flood control channels, effects of sediment maintenance in the channels is presumed to have little or no effect on listed salmonid species. Effects to salmonids are evaluated for direct injury to fish and for long-term changes to habitat.

Direct Injury to Fish

Direct effects of sediment removal are evaluated based on the level of instream and upslope sediment control and on the opportunity for injury to fish. Injury to fish can be caused by increases in turbidity and sediment input, stress from displacement, or direct injury or mortality from maintenance equipment. When sediment maintenance activities occur in streams with flowing water, flow would be bypassed around the work area. Alternatively, sediment containment may consist of the placement of barrier across the channel. This type of barrier slows the water flow, allowing suspended sediment to settle out where it can be cleared following maintenance activities. The current sediment containment practices are likely to result in effective sediment control, because they allow a limited amount of fine sediment to be introduced within the immediate area. Therefore, the score for sediment removal practices for component 1 of the sediment containment evaluation criteria is 3 (Table 5-36) (see Appendix C for a detailed discussion of evaluation criteria).

The use of heavy equipment on a streambank could potentially result in “upslope” disturbance (for sediment-removal activities in flood control channels, upslope is synonymous with the streambank). SCWA would not use equipment on the streambank, but rather would continue to work from service roads adjacent to the channel or within the channel bottom. Occasionally, construction of a new access road to the stream bottom may be necessary, however, disturbance of the streambank would be limited to discrete areas. The use of existing access roads limits the amount of streambank disturbance, protecting vegetation and soil structure. Therefore, the risk of a direct effect on rearing salmonids due to this type of activity is low. Component 2 of the sediment containment evaluation criteria receives a score of 4 (Table 5-36).

Sediment removal and channel-clearing activities have the potential to injure or kill fish when equipment is operated in the channel. Fish that would be temporarily displaced may be subjected to stress, increased competition, or predation. SCWA biologists would assess habitat conditions prior to sediment removal to determine if listed fish species are present in the maintenance area. In past inspections, SCWA has found that salmonids are not usually present in these areas during the time of year that the work is performed (A. Harris, SCWA, pers. comm. 2000). If listed salmonids are present, a barrier would be established to exclude fish from the immediate area of the activity, and a fish rescue would be performed, if necessary. Because efforts would be taken to avoid effects on listed species by exclusion from the area affected or relocation to other habitat, the risk of injury would be low. Therefore, sediment removal and channel-clearing activities receive a score of 3 (Table 5-37).

Table 5-36 Sediment Containment Evaluation Scores for Sediment Removal

Category Score	Evaluation Category	Current Operations Score*
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	Co, St, Ch
2	Limited sediment control.	
1	No instream sediment control.	
	Component 2: Upslope Sediment Control	
5	No upslope disturbance, or an increase in upslope stability.	
4	Limited disturbance with effective erosion control measures.	Co, St, Ch
3	Moderate- to high-level of disturbance with effective erosion control measures.	
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel or major changes in channel morphology.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Table 5-37 Opportunity for Injury Evaluation Scores for Sediment Removal

Category Score	Evaluation Category	Current Operations Score*
5	Project area is above the high-flow WSE defined by the 1.5 bankfull event and/or above the tops of bars, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	Co, St, Ch
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

The level of risk for injury to fish depends, in part, on how much of the channel would be "cleaned" and how often the work would be performed. Table 5-38 lists the constructed flood control channels and provides estimates on the extent and frequency of sediment removal activities. Many of these channels have never required sediment maintenance (i.e., they are self-maintaining). Some require maintenance every year.

Table 5-38 Frequency and Extent of Sediment Removal in Constructed Flood Control Channels (as of 2003)

Creek	Total Constructed Channel Length (ft)	Percent of Channel Worked	Average Bottom Width (ft)	Frequency of Work	Recently Cleaned*	Comments
Santa Rosa Area Streams						
			Rearing and/or Spawning Habitat			
Brush	12,100		25	>20 yrs		Self cleaning
Oakmont	6,600		20	> 10 yrs		Hydraulic only/ no sediment removal
Paulin	15,400		20	>20 yrs		Self cleaning
Piner	12,000	50%	20	>10 yrs	1989	Remove sand bar at Sleepy Hollow Ct.
Santa Rosa	48,400		30/40	>20 yrs		Self cleaning
Todd	15,400	40%	20	5-10 yrs		Not cleaned in last 5 years
			Migration Only			
Austin	5,000		20	>20 yrs		Self cleaning
Colgan	19,250	50%	30	5-10 yrs	2000	From Stony Point Rd to Llano Rd.
College	4,400		15	>20 yrs		Self cleaning
Forestview	3,850			>20 yrs		Self cleaning
Indian	1,650	100%	10	>10 yrs	1999	From Piner Rd. north 2,000 ft
Kawana Springs	2,200	100%	20	10-20 yrs	1988/89	Petaluma Hill to Colgan Creek
Lornadell	1,200	100%	15	5-10 yrs	1987/88	Not cleaned in last 5 years
Matanzas	2,500	100%	35	>10 yrs	1988/89	Last cleaning
Peterson	8,800		15	>20 yrs		Self cleaning
Roseland	23,000		25	5-10 yrs		Not cleaned in last 5 years
Russell	3,800	100%	15	5-10 yrs	1989/97	From Mendocino Ave to Indian Creek
Sierra	1,600		15	>20 yrs		Hydraulic only/ no sediment removal
Steele	12,000	20%	15	10-20 yrs	2003	
Wendell	6,100	50%	15	5-10 yrs		Not cleaned in last 5 years
Windsor	5,000	50%	20	5-10 yrs		Not cleaned in last 5 years

Table 5-38 Frequency and Extent of Sediment Removal in Constructed Flood Control Channels (as of 2003) (Continued)

Creek	Total Constructed Channel Length (ft)	Percent of Channel Worked	Average Bottom Width (ft)	Frequency of Work	Recently Cleaned*	Comments
Cotati-Rohnert Park Area Streams						
Rearing and/or Spawning Habitat						
Laguna de Santa Rosa	24,200	10%	40	5-10 yrs	1992/93	East Cotati Ave to Commerce Blvd.
Migration Only						
Coleman	3,300		20	1-5 yrs	1997	Cleaned upper reach 2 times in Golis Park in last five years
Copeland	19,250	100%	30	1-3 yrs	2000	Commerce Blvd to Jasmine Ct. 12,100 ft
Copeland South Fork	4,000	100%	15	10-20 yrs	1986/87	Last cleaning
Cotati	1,000	100%	15	5-10 yrs		Not cleaned in last 5 years
Crane	800	100%	15	5-10 yrs	1991/92	Not cleaned in last 5 years
Five	6,600	100%	25	5-10 yrs	2000	From Snyder to Country Club
Gossage	7,700	90%	15	5-10 yrs	1989/98	Gravenstein Hwy (Hwy 12) to Laguna de Santa Rosa
Hinebaugh	13,200	25%	25	1-5 yrs	1989,95, 99	3 separate reaches of approximately 1,000 ft
Hunter Lane Channel	6,600	100%	20	5-10 yrs	2000	Santa Rosa Ave to Hunter Lane
Spivok	1,600		10	5-10 yrs		Not cleaned in last 5 years
Washoe	1,600	100%	15	5-10 yrs		Not cleaned in last 5 years
Wilfred	22,000	100%	15	5-10 yrs	1989/95	From Laguna de Santa Rosa to Snyder Lane
Healdsburg Area Streams						
Norton Slough	6,600	100%	20	1-5 yrs	1987/88, 2001	Planned for future
Windsor Area Streams						
Starr	2,500	100%	15	10-20 yrs	1985/86	Last cleaning
Geyserville Area Streams						
Woods	3,500	30%	15	1-5 yrs	1995, 98, 99	Cleaned approx 500 ft near rail road tracks

*Some creeks that have not required recent cleaning may require cleaning in the future.

Overall, sediment removal activities may adversely affect a few individual juvenile coho salmon, steelhead, or Chinook salmon, but are not likely to result in a population-level effect for any of the three listed species. Disturbance to the streambank would be kept to a minimum, and effective sediment control practices would be used during instream work in wetted channels. Channels would be assessed by SCWA biologists before sediment removal activities would be performed, and in the rare instances that it is determined that listed species are likely to be present, a barrier would be established to exclude fish and, if necessary, rescue would be performed. To date, barriers and fish rescues have not been necessary (S. White, SCWA, pers. comm. 2004). Because sediment-laden constructed flood control channels do not generally provide rearing habitat for coho salmon or steelhead, they are likely to have few, if any fish present, so the risk for injury to fish is low. While some individual fish may be exposed to injury, there is low risk to any of the populations of listed fish species, as a whole.

Long-Term Changes to Habitat Associated with Sediment Removal

Under baseline practices, sediment maintenance activities would remove all sediments from constructed channels to maintain channel capacity. Under the proposed project, sediment removal would only be conducted on an as-needed basis, which could result in less intensive sediment removal in some channels. Sediment removal activities that may have long-term habitat effects on fish migration include reduction of habitat complexity such as loss of a low-flow "thalweg" needed to provide fish passage, and loss of instream cover (rocks, vegetation). In the past, such habitat features were often removed within reaches that were excavated. Under the proposed project, where possible, a meandering thalweg would be left to provide for fish passage. However, in the few areas where more extensive sediment removal may have to occur to maintain channel capacity, the loss of a low-flow channel may result in a loss of fish passage opportunities. The effects of sediment maintenance activities were evaluated, based on the amount of work that would be needed and on available information on salmonid use of a particular stream.

Table 5-38 lists the constructed flood control channels and the estimated frequency of maintenance related to sediment removal (P. Valente, SCWA, pers. comm. 2003). Estimates of the channel length (defined as a percentage of total channel length) where work is usually performed are indicated. This percentage does not represent a continuous length of channel in which sediment would be removed, since the actual maintenance work typically would be performed at discrete, selected sites. Only that portion of the channel reach that is hydraulically impaired would be cleaned. The frequency and length of work varies over time. In the past, flood control channels were cleaned at least once every five years. Currently, channel cleaning would be restricted to an as-needed basis to maintain flood capacity. For example, 100 percent of Copeland Creek (i.e., 100 percent of the constructed flood control channel) was cleaned once in 1997, but only 17 percent (2,000 feet) required cleaning in 2000. The frequency of work may change in the future if land-use practices or development occurs that alters sediment supply conditions in the sub-basins draining the flood control channels.

One of the largest recent sediment removal activities was performed in 1997 in a 2.5-mile stretch of Copeland Creek located upstream of Petaluma Hill Road outside of Rohnert

Park. Sediment input from a large runoff area upstream resulted in significant sediment loads being delivered to the creek (R. Anderson, SCWA, pers. comm. 2000). SCWA worked on restoring approximately 6,000 feet of streambank upstream on Copeland Creek to reduce streambank erosion (see Section 5.5 for details of this and other erosion control projects). However, low summer flows and high summer water temperatures may limit rearing habitat in the restored reach of Copeland Creek.

Sediment was removed from a wide section of Hinebaugh Creek west of the freeway in 1999. Sediment is deposited there when backwater from Laguna de Santa Rosa enters the creek. Coleman Creek has a short segment of constructed channel through a local golf course that requires sediment removal activities. Increased sedimentation in this creek may be due to upstream development. It is expected that the Cook Creek Conduit Sediment Basin upstream of Rohnert Park, completed in 1998, will help to reduce some of the sediment input to Coleman Creek.

Most of the constructed flood control channels that are subject to frequent sediment removal activities function primarily as migration corridors for upstream and downstream migrants during the winter and spring. Summer rearing habitat and spawning habitat is not typically found in constructed channels subject to sediment removal.

<u>Effects on Salmonid Migration</u>

In general, sediment removal activities are needed in channel reaches that contain poor habitat and significant sediment deposition. These channels function primarily as migration corridors. Small lateral bars are observable in many locations along the channel bottom. These deposits are usually stabilized by either grasses or tules. The sediment deposits are primarily silt and clay. These small lateral bars and other deposits narrow the bottom width of the channel, and tend to create a more “natural” sinuous low-flow path within the straight flood control channel.

Observations made following sediment removal activities indicate that the channel bed is devoid of the small lateral bars and associated in-channel vegetation. The loss of a sinuous, narrow, low-flow channel allows the streamflow to spread over the bottom width, reducing depth. This reduction of flow depth creates a fish passage barrier when runoff is relatively low. Reduced depth of flow can be expected to occur whenever lateral bars are removed, eliminating a low-flow thalweg and widening the channel bottom. As a result, migration is limited to periods when flows are higher and depth is adequate for passage.

Lateral bar features eventually become reestablished following runoff events capable of mobilizing and redistributing bed sediments, and vegetation has had an opportunity to colonize and stabilize the bars. Vegetation on the streambed bars may take more than one season to become reestablished.

The post-sediment removal effects on passage conditions were evaluated on Copeland Creek and Five creeks. Sediments were excavated from sections of both channels during fall 2000. Following sediment removal, water depths in the excavated portions of both streams were estimated to average 2 to 3 inches during a field inspection. In the unexcavated portions of these channels, depths were a minimum of 6 inches. Figure 5-55 shows an excavated section of Copeland Creek with a wide, shallow, and flat streambed in December 2000. Figure 5-56 shows an unexcavated section of Copeland Creek from the same date, with a narrowed channel bottom and vegetated lateral bars. Steelhead generally require a minimum of 6 inches of depth for migration (Flosi et al. 1998).

Given the 2- to 3-inch depths observed on Copeland and Five creeks, fish passage is likely to be impaired following sediment maintenance. Based on the types of habitat alteration that occurs, sediment removal can negatively affect migration in constructed flood control channels during low flows.

SCWA is evaluating the possibility of reestablishing some sinuosity to low-flow channels within the wide streambeds of the flood control channels following sediment maintenance activities. Outside bends would be stabilized with natural materials to produce longevity of the meander patterns. This action would create increased depth in the corner pools and overall, to allow improved fish passage and juvenile rearing conditions.

<u>Effects on Rearing and Spawning Habitat</u>

Of the stream channels identified that potentially support salmonid rearing habitat only two have required frequent (once every 5 to 10 years) sediment removal activities in the recent past, although additional channels may require more frequent maintenance in the future for flood control. The two channels are Laguna de Santa Rosa in the Rohnert Park area and Todd Creek in the Santa Rosa area. The basis for identifying these channels as potentially supporting rearing habitat is that they either maintain flow through the summer season or steelhead have been known to occur in them. Both channels are likely to require additional sediment maintenance in the future. The remaining channels that potentially support salmonid rearing habitat have been maintained less frequently (once every 10 to 20 years). Rearing habitat could be disturbed in these channels, and the effects of that disturbance may persist for several years. However, primary rearing habitat is not expected to be found in these constructed flood control channels, so the loss of some rearing habitat would not be substantial.

Spawning habitat is generally not present in the constructed flood control channels that require sediment maintenance, for reasons similar to those discussed regarding the lack of rearing habitat. Low-gradient, straightened channels that are subject to sediment deposition do not generally provide any or good spawning habitat conditions. Observations of flood control channels indicate that suitable spawning sites such as gravel deposits at pool tailouts are very infrequent and limited in extent. Lack of hydraulic complexity probably accounts for limited sites where sorting of gravels forms suitable spawning riffles. This is due to the straight channel and entrenched (vertical containment) geomorphic condition of the flood control channels. There are no known reports or observations of spawning occurring in constructed flood control channels that

Figure 5-55 Copeland Creek downstream from Snyder Lane, December 2000. Channel reach was excavated in October 2000.

Figure 5-56 Copeland Creek downstream of Country Club Drive, December 2000. This reach of Copeland Creek has not been recently excavated. Note the vegetated lateral bars and the narrowed channel bottom.

require sediment excavation. Of the constructed flood control channels, Oakmont, Paulin, and Santa Rosa creeks are believed to provide salmonid spawning habitat. However, these channels generally have been maintained infrequently (once every 10 to 20 years).

While the availability of spawning habitat may potentially be reduced in some years, the activities occur infrequently so the effects on the availability of spawning habitat would not be high. Because the availability of rearing habitat is more likely to be the limiting factor for salmonids than the availability of spawning habitat, the effects to listed fish species is likely to be low.

Sediment removal in Todd Creek and Laguna de Santa Rosa could reduce rearing habitat by eliminating pools and associated cover within the excavated reach. Sediment excavation flattens the bed topography, reducing hydraulic and habitat complexity. This is likely to be a significant effect for coho salmon and steelhead, which are the two listed fish species most likely to be present in these channels. The effect would be localized in the excavated reach only and not extend to areas downstream.

Sediment excavation does not affect other aspects of channel geomorphology or aquatic habitat downstream of the excavated reaches. Observations of the flood control channels indicate that there are relatively few sites where sediment deposition occurs within the well-entrenched and straightened flood control channels. There is also very little evidence of channel incision due to sediment excavation based on the inverts of culverts and bridge crossing structures. Excavation has apparently not significantly reduced sediment supply to reaches downstream of maintained areas. Additional sediment that would be transported downstream if this maintenance activity ceased would most likely lead to channel aggradation, and possibly increased erosion of channel banks. This would cause a loss of not only channel flood capacity, but would allow additional sediments to reach Laguna de Santa Rosa and ultimately the Russian River. The Russian River drainage is identified by the NCRWQCB (Section 303-D) as impaired for sediment.

5.4.2.2 Vegetation Maintenance in Constructed Flood Control Channels and Natural Waterways

Vegetation maintenance practices differ between natural waterways and constructed flood control channels. Salmonids use both types of channels for migration, although rearing and spawning is known to occur in only a few flood control channels. Removal of riparian vegetation has the potential to reduce cover for rearing salmonids, increase water temperatures, reduce the input of vegetation on aquatic insects that support the food chain for salmonids, and decrease bank stability (in natural waterways), which increases the potential for erosion and sedimentation.

The assessment of vegetation maintenance effects was organized into the two principal channel groupings: constructed flood control channels and natural waterways. The assessment of direct immediate effects to fish populations associated with herbicide spraying in natural waterways was also evaluated.

Constructed Flood Control Channels

Short-Term Direct Effects of Vegetation Removal

The principal short-term direct effect of vegetation control in constructed flood channels would be the potential for direct injury to fish from the introduction of herbicides into streams. In the past, access roads were sprayed with long-lasting herbicides that are toxic to fish and aquatic insects if they were to leach into the stream. Since the early 1990s, only an EPA-approved, glyphosate-based, aquatic contact herbicide (such as Rodeo™) has been used. An herbicide such as Rodeo is much more expensive than some herbicides, but substantially reduces the risk to listed species and aquatic life that supports their food chain. An aquatic contact herbicide would continue to be used in the bottom of narrow channels, as well as hand-clearing, particularly to remove cattails.

Maintenance activities have the potential to introduce herbicide to the channel. Roads will continue to be sprayed with an herbicide approved for aquatic use and mowed once a year, beginning in summer and continuing to the fall. The herbicide would be sprayed in a narrow width, and care would be taken to not spray the herbicide too close to the edges of creeks. Residual vegetation would then mowed. The area between the access roadways and the fence lines that border the channels would be mowed annually. As glyphosate degrades relatively quickly, it is unlikely that herbicide would leach into the channel. The roads adjacent to the low-flow channels in Rohnert Park would be mowed, but no herbicide would be applied. Therefore, a score of 4 was assigned to this limited use of an aquatic use approved rapidly degrading herbicide (Table 5-39).

Table 5-39 Vegetation Control Scores Associated with Herbicide Use

Category Score	Evaluation Criteria Category	Current Operations Score
5	No chemical release.	
4	Limited use of herbicide approved for aquatic use.	Co, St, Ch
3	Moderate to heavy use of herbicide approved for aquatic use.	
2	Use of herbicide not consistent with instructions.	
1	Use of herbicide not approved for aquatic use.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook

Long-Term Indirect Habitat Effects Associated with Vegetation Maintenance Practices

This section evaluates effects of three levels of vegetation maintenance: original design capacity, intermediate, and mature riparian vegetation maintenance. The evaluation considered effects that would occur based on projected maintenance needs for channels that are likely to contain habitat for salmonids. Future vegetation maintenance in some of these channels may be modified to allow the growth of more vegetation, depending on ongoing assessment of hydraulic capacity.

Frequency of vegetation control work was estimated for constructed flood control channels in which vegetation removal activities would occur (Table 5-40) (B. Oller, SCWA, pers. comm., 2003). Where rearing or spawning activity is known or suspected to occur, it is indicated. The presence of continuous summer flow (streamflow that is not supported by urban return flows) was another factor considered.

Most of the flood control channels, except Paulin, Piner, Santa Rosa, and Oakmont creeks, have conditions unsuitable for spawning because of very low gradients (between 0.05 percent and 0.4 percent foot per foot). These channels generally lack the riffles or pool-tailouts where spawning habitat is most likely to occur. Salmonids may use some constructed flood control channels as migration corridors to and from upstream spawning and rearing habitats. Channels that may potentially support summer salmonid rearing habitat within or upstream of the maintained portion but may require the original design maintenance scenario include Paulin, Piner, Santa Rosa, Brush, Crane, Laguna de Santa Rosa, Rinconada, and Todd creeks (Table 5-40).

In the past, vegetation has been maintained at the original design maintenance level to preserve the original hydraulic capacity (flood way) and reduce fire dangers. Under the proposed project, vegetation maintenance practices would be adjusted to provide better habitat conditions where feasible. Vegetation maintenance would be keyed to the channel zone and the amount of hydraulic capacity needed. Additional riparian vegetation at the intermediate or mature riparian vegetation maintenance levels would be allowed to develop, resulting in increased canopy cover in many channels. Under the proposed project, hydraulic capacity assessments would be conducted to determine the level of flood capacity needed, and this information would be used to evaluate the level of vegetation maintenance needed. Some streams that currently experience frequent vegetation clearing could be managed in a way that allows more vegetation to develop in the appropriate channel zones while preserving needed hydraulic capacity, as described in Section 4.4.

Scores for the three levels of vegetation management: original design, intermediate, and mature, are presented in Table 5-41. Under the mature riparian vegetation management, a mature riparian corridor would be allowed to develop, for a score of 5 or 4. Intermediate vegetation management would allow some vegetation to develop. Based on the estimated 30 percent of the vegetation along the channel cross section that is removed from flood control channels under current maintenance practices, the overall score for vegetation control practices would be 3. However, some channels may require more vegetation to be removed, for a score of 2.

Original design management would generally maintain the channel at or near the original design capacity of the channel. With the original design maintenance level, it will be necessary for SCWA to remove vegetation in the channel such that only vegetation near the top of the bankfull channel, and set back from the top of the bank, would be allowed to establish. This would represent approximately a 75 percent or greater reduction in vegetation within the channel cross section. The resulting score would be 1, indicating a

Table 5-40 Levels of Vegetation Maintenance Work in Flood Control Channels[1]

Creek	Summer Flow[2]	Species Known to Occur[3]	Potential to Support Spawning/Rearing Habitat
Streams that Require Original Design Maintenance Scenario			
Migration, Rearing, and Spawning			
Paulin	Yes	St	Yes
Piner			Yes
Santa Rosa	Yes	Co, St, Ch	Yes
Migration and Rearing			
Brush		St	Yes
Crane			Yes
Laguna de Santa Rosa	Yes	St	Yes
Rinconada	Yes		Yes
Todd		St	Yes
Migration Only[4]			
Austin[5]		St	Yes
Coleman			
Colgan			
Copeland			
Cotati			
Ducker			
Five			
Forestview			
Hinebaugh		Ch	
Kawana			
Lornadel			
Roseland			
Gossage / Washoe			
Wilfred	Yes		
Windsor	Yes		
Streams that Require Intermediate Vegetation Maintenance			
Migration, Rearing, and Spawning			
Oakmont	Yes		Yes
Migration Only[4]			
College			
Faught			
Hunter Lane Channel		St, Ch	Yes
Indian			
Peterson			
Russell			
Spivok			
Starr			
Steele			
Wendel			
Windsor tributaries			
Streams with Mature Riparian Vegetation Management			
Sierra Park			
Spring			
Wikiup			

1 Source: SCWA (Paul Valente and Bob Oller, Operations & Maintenance Department).
2 Summer base flow that is not supported by relatively recent urban runoff. Portions of these channels dry up in summer, but other portions retain base flow.
3 Where rearing activity occurs, species are listed if known. Salmonids may use other channels currently or in the future. Co = coho salmon; St = steelhead; Ch = Chinook salmon
4 Migration corridor assumed to be a function of all flood control channels.
5 Austin Creek in Rincon Valley, not in West Sonoma County.

Table 5-41 Vegetation Control Scoring for Flood Control Channels

Category Score	Evaluation Criteria Category	Score
5	No removal except selectively along access roads, fencelines, "spot" treatments, or to remove non-native species.	Mature riparian vegetation management
4	<25% reduction in vegetation.	Mature riparian vegetation management
3	>25% to <50% reduction in vegetation.	Intermediate vegetation management
2	>50% to <75% reduction in vegetation.	Intermediate vegetation management
1	>75% reduction in vegetation.	Original design management

potentially significant effect on listed salmonid species and their habitat. It is recognized that there is a potential for greater effects on habitat conditions associated with those channels that are most likely to support rearing or spawning habitat.

Vegetation removal on some channels under this level of vegetation maintenance would result in increased water temperatures that could be detrimental to salmonids. Removal of understory vegetation may result in a decrease in cover for salmonids and habitat for invertebrates on which the fish feed.

Under the intermediate or mature riparian vegetation management, shade canopy may become established in some of these flood control channels due to tree growth on the streambanks. Under these conditions, it is expected that there would be less need to remove understory vegetation, and therefore, reductions in canopy cover would become less frequent. Modified vegetation maintenance practices are likely to increase the long-term habitat value of channel reaches over existing conditions by increasing canopy cover, and decreasing water temperatures in the summer. Also, by targeting non-native vegetation for clearing and allowing native species to become established, the chances for a naturally functioning ecosystem to become established increase. The effect of reestablishing a naturally functioning ecosystem would be of particular benefit to coho salmon, steelhead, and Chinook salmon. These effects are already being seen in Brush, Santa Rosa, and Hinebaugh creeks where significant tree growth has occurred.

Existing vegetation maintenance practices in constructed flood control channels have been reviewed by SCWA to determine their influence on channel flood capacity. Vegetation growth must be balanced with flood capacity. As vegetative growth on the streambanks become more dense and mature, channel capacity could be significantly reduced, and flooding could occur. In order to prevent flooding and maintain flood capacity, the original design capacity maintenance practices would be required in some segments of constructed flood control channels.

Most flood control channels that require frequent or extensive maintenance do not provide good quality spawning and rearing habitat. Some flood control channels have poor habitat in the constructed portion of the channel, but may have spawning or rearing habitat in the upper portion. In these, the primary effect of vegetation management in the constructed channel would be on upstream or downstream migrants.

Effects would be of greater significance to populations as a whole for those flood control channels that support rearing and/or spawning habitat. Ten flood control channels have been identified that potentially support spawning and/or rearing habitat, nine of which have reaches that require the original design maintenance scenario:

- Brush
- Crane
- Laguna de Santa Rosa
- Oakmont
- Todd
- Paulin
- Piner
- Rinconada
- Santa Rosa
- Hunter Lane

In some cases, vegetation maintenance is conducted in a small area. For example, the area below Brush Creek encompasses approximately a 50-foot radius. Removal of brushy vegetation from such a small area is not likely to affect salmonid habitat, particularly since these areas are dry during the summer and no fish rearing would take place at that time. Removal of non-native weeds (like hydrilla) may benefit salmonid habitat downstream, as does removal of fine-grained sediments.

Evaluation criteria provide an estimate of the long-term indirect effects on habitat depending on the extent of vegetation removal practices. For some of the flood control channels that do not support rearing or spawning habitat, there may be an effect on salmonid migration. In those channels where a low-flow thalweg can be maintained, fish passage may not be substantially affected. For segments of the nine of the ten channels that have been identified as providing potential rearing and/or spawning habitat, the original design maintenance practices may have localized effects that would be greater.

Natural Waterways

Table 5-40 lists the natural waterways maintained by SCWA in the Russian River watershed. Past practices that may have resulted in degradation to native riparian vegetation and to instream vegetation on natural waterways have been greatly modified. Previously, riparian vegetation was extensively removed. Under the proposed project, protocols would be implemented to retain as much canopy cover as possible (see Section 4.4). Vegetation would be removed by hand, brush would be removed, and trees and limbs would be removed only if required for flood protection. SCWA maintenance practices include a buffer strip of vegetation along the low-flow channel margin. Efforts would be made to preserve the natural habitat for fish and riparian wildlife. These activities are not expected to result in direct injury to listed species. SCWA has coordinated in-channel vegetation maintenance with NOAA Fisheries. Several alternative vegetation maintenance methods are being considered, including selective vegetation removal based on vegetation density, height, or stem diameter. Along streambanks, understory vegetation (blackberries and willows) is removed, but native trees are retained to provide canopy cover along natural waterways.

Although limited vegetation removal in isolated sites may not negatively affect salmonid habitat, work done over several sections of a stream and/or in prime spawning and rearing habitat, may have a larger net effect. For example, if willows are removed from several gravel bars to reduce the potential for streambank erosion in an important coho salmon stream, the net effect may be to significantly alter channel morphology, the amount of instream cover, and the availability of refugia from high flows. To avoid significant effects to salmonid habitat, vegetation removal in natural waterways would be kept to a minimum and used only when the hydraulic capacity of the channel does not meet the original design flood capacity (typically 100-year flood event on most channels) or where a decrease in bank stability threatens a structure. For most projects, vegetation maintenance would be conducted within stream reaches that are each between 300 and 600 feet in length.

Vegetation Maintenance Scores Associated with Natural Waterways

Current practices emphasize retention and creation of a shade canopy over stream channels to reduce plant growth on the channel bottom and to benefit salmonid habitat quality. Native trees are allowed to establish, and understory in the channel and along the banks is judiciously removed. Generally, the understory is thinned and lower limbs on trees are pruned (to raise the canopy) to improve flood capacity.

For the natural waterways where vegetation removal may occur SCWA removes vegetation on these other natural waterways only where there are site-specific problems with flood capacity or bank stability. Therefore, the length of vegetation removal would be limited to small projects, generally 300 to 600 feet in length. It is difficult to estimate the percentage of vegetation that may need to be removed in a cross sectional area from any of these given channels because they vary in maintenance needs. However, since SCWA practices in natural waterways call for underbrush removal and retention of a shade canopy over stream channels, it is reasonably estimated that no more than 25 percent of the in-channel vegetation would be removed, resulting in a score of 3 (Table 5-42).

Table 5-42 Vegetation Control Scores for Natural Waterways

Category Score	Evaluation Criteria Category	Score
5	No vegetation removal except "spot" treatment, or removal of only non-native species.	
4	<10% reduction in vegetation.	
3	>10% to <25% reduction in vegetation.	St, Co, Ch
2	>25% to <50% reduction in vegetation.	
1	>50% reduction in vegetation.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

While individual projects may be small, the sum of several projects may have larger effects, especially if they occur in important salmonid spawning and rearing habitat such as some of the natural waterways in Mark West Creek and its tributaries or the natural waterways in the western, coastal-fog influenced portions of the watershed. Therefore, removal of instream and streambank vegetation would be kept to a minimum in these streams (i.e., only where significant flood control hazards or threats to structures exist). Vegetation removal in streams with limited rearing habitat (for example, some natural waterways in the Rohnert Park area) would not be as likely to diminish salmonid habitat, and therefore could safely be more extensive. Current vegetation removal activities, therefore, have a relatively low risk of short-term or long-term indirect effects to salmonid habitat (particularly coho salmon and steelhead) in natural waterways.

Herbicides may be selectively used in natural waterways to reduce dense stands of *Arundo*, cattails, and blackberries. Spraying in natural waterways would be done only when the channel flood capacity has been significantly reduced. This practice has become more common on streams where urban or irrigation return flows support vegetative growth throughout the summer. When spraying is necessary in natural waterways, it would be conducted in focused areas, generally for project lengths of 100 to 500 feet of stream (B. Oller, SCWA, pers. comm. 2000). A score of 4 is therefore given for herbicide applications in natural waterways (Table 5-43), due to the very limited, infrequent and site-specific extent of use with approved herbicides. A score of 4 for herbicide use indicates that only minor effects to listed salmonid species are expected to occur as a result of this action.

Table 5-43 Vegetation Control Scores Associated with Herbicide Use

	Herbicide use	
5	No chemical release.	
4	Limited use of herbicide approved for aquatic use in riparian zones or over water.	Co, St, Ch
3	Moderate to heavy use of herbicide approved for aquatic use in riparian zones or over water.	
2	Use of herbicide not consistent with instructions.	
1	Use of herbicide not approved for aquatic use in riparian zones or over water.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

In some cases, restoration projects have increased riparian cover, maintained hydraulic capacity, and reduced the need for streambank or streambed maintenance activities (see Section 5.5). For example, restoration activities in Brush Creek showed that planting native trees in a straight line parallel to the stream increased riparian habitat value of the stream without significantly decreasing the hydraulic capacity. When native trees are established, either through restoration activities or through channel maintenance practices that allow native riparian vegetation to establish itself, it is expected that the need for vegetation removal activities will decrease and the fish habitat value of these streams will significantly increase. As SCWA biologists continue to work with channel maintenance personnel to restore native vegetation, the habitat value of both natural and constructed flood control stream reaches would be expected to improve over baseline conditions.

5.4.2.3 Large Woody Debris Removal

Debris removal, particularly large woody debris removal, would be conducted only when the debris poses a threat for erosion or flood control. Before large woody debris would be removed, it would be evaluated by SCWA staff. Large woody debris would be removed with a winch from the top of the bank, cut up, and transported away.

Large Woody Debris Removal in Flood Control Channels

Large woody debris plays a relatively small role in the structure and function of salmonid habitat within the Zone 1A (see Figure 3-6) flood control channels for several reasons:

- Flood control channels are not within forested regions that are sources of large woody debris.
- Flood control channels are designed to be stable so that bank erosion and associated large woody debris recruitment is minimal.
- Flood control channels are designed to contain large peak annual floods (10-, 25-, or 100-year runoff events), so that high flows prevent large woody debris from lodging in stable positions in the channel.

Typical large woody debris recruitment processes, whereby bank erosion helps large woody debris recruitment to streams, does not occur very often in flood control channels. SCWA estimates that an average of half a dozen pieces are removed from flood control channels, annually, and fewer in years with smaller storms.

Constructed flood control channels were designed to efficiently pass high flows in relatively “flashy” watersheds that are also efficient at passing even large trees. While some large woody debris may be deposited in the Laguna de Santa Rosa, most of it is washed to the Russian River. Some large woody debris from the upper watershed, such as the Hood Mountain area, is caught on trash racks or deposited in Spring Lake. This wood would continue to be removed and cut up. The effect of the flood control reservoirs on the recruitment of large woody debris is evaluated in Section 5.4.2.

Large woody debris is not likely to play a significant role in providing structure or habitat in flood control channels. This is the case today and would likely persist into the future, given the limited tree resources and recruitment processes. Therefore, the SCWA practice of limiting large woody debris removal to situations when it poses a flood control hazard would not likely result in substantial reduction of cover or scour, and the maintenance activity score is 3 (Table 5-44). The only species/lifestage that may be affected by removal of large woody debris in flood control channels would be young steelhead rearing near the debris. Removal of large woody debris can potentially reduce the amount of instream cover and habitat diversity for salmonids, as well as substrate for benthic invertebrates that serve as food. Large woody debris creates hydraulic gradients that increase microhabitat complexity and the abundance of salmonids is often linked to the abundance of woody debris, especially in the winter (Bustard and Narver 1975, Tschaplinski and Hartman 1983, Murphy et al. 1986, Hartman and Brown 1987).

Table 5-44 Large Woody Debris Removal Scores

Category Score	Evaluation Category	Current Operations Score
5	No large woody debris removal or modification.	
4	Large woody debris not removed, but modified.	
3	Large woody debris removal limited to only when it poses a flood control hazard, removal does not result in substantial reduction of cover or scour in the area.	St
2	Large woody debris removal limited, but potentially results in moderate reduction of cover or scour.	
1	Complete removal of large woody debris resulting in substantial reduction of cover or scour.	

*St = Steelhead

5.4.2.4 Central Sonoma Watershed Project Flood Control Reservoirs

Four flood control reservoirs passively reduce flooding in the Santa Rosa area during the rainy season. Three of these reservoirs are instream with minimum streamflow bypasses. These three reservoirs are impassable, acting as barriers to upstream migration for anadromous coho salmon and steelhead. A diversion structure on Spring Creek also acts as a barrier to upstream migration. Potential downstream effects of operation and maintenance on anadromous salmonids and their habitat were evaluated. Additionally, safe fish passage for downstream migrants in Santa Rosa Creek past the Spring Lake diversion was evaluated.

Brush Creek and Piner reservoirs and the Spring Creek diversion are located on ephemeral streams and are relatively small reservoirs that dry up by the summer. Matanzas and Spring Lake reservoirs have larger capacities, do not dry up during the summer, and do not spill downstream during the summer season. The Sonoma County Park Department adds water (after October when peak water demands are reduced) to maintain a recreational lake. A small tributary spring at the Spring Lake diversion facility also feeds water to Spring Lake. Spring Lake is located offstream and receives water from Santa Rosa Creek only during high flows that occur about once a year (A. Harris, SCWA, pers. comm., December 24 2003).

Evaluation of Immediate, Direct Effects of Maintenance Activities of Flood Control Reservoirs

An evaluation of direct effects of maintenance activities at these flood control reservoirs is presented in *Interim Report 5: Channel Maintenance* (ENTRIX, Inc. 2001b). No changes are planned for facilities or operation of these flood control reservoirs, future effects due to maintenance activities should be similar to the baseline condition *Interim Report 5*.

Maintenance activities would include silt removal and removal of noxious pondweeds. Silt, debris, and vegetation removal would also be performed at the inlets and outfalls to the reservoirs.

Sediment and weed removal from flood control reservoirs would not increase turbidity or cause downstream sedimentation because there is no flow from the work area. Listed fish species would not be injured during maintenance activities because there are no anadromous runs of salmonids past the structures on Brush, Paulin, Matanzas, or Spring creeks. Salmonids trapped in Spring Lake would be lost to the anadromous population, and this effect was evaluated separately.

When the large, shallow Spring Lake is drained for maintenance work, it has the potential to increase water temperatures in Santa Rosa Creek. It may take 4 to 6 weeks to drain the reservoir, and this activity may occur about once every 12 years. Spring Lake would be drained as early as possible in the spring while water temperatures are cooler and creek flows are higher to avoid increasing summer water temperatures above threshold limits for salmonids.

In general, maintenance activities would not directly affect salmonids. While there would likely be an increase in water temperature in Santa Rosa Creek when Spring Lake is drained, this increase is unlikely to exceed thresholds that are suitable for salmonid rearing. The water would be released as early as possible in the spring when water temperatures are still cool.

Evaluation of Effects on Fish and Long-Term Habitat Alteration from Passive Operation of Flood Control Reservoirs

A detailed evaluation of the effects on listed species and long-term habitat alterations that result from passive operation of the flood control reservoirs and criteria and effects scoring are presented in *Interim Report 5: Channel Maintenance* (ENTRIX, Inc. 2001b). No changes to passive operation of the flood control reservoirs are planned so future effects on the listed salmonid species and their habitat would be similar to those described in *Interim Report 5*.

Attenuation of peak floods is not likely to negatively affect downstream channel geomorphology through alteration of channel maintenance flows. Only a small drainage area is captured by the Brush Creek and Piner Reservoir, so that peak floods are probably not significantly altered and resulting downstream effects are not likely to be significant. Matanzas Creek Reservoir generally fills and spills after mid-December, so channel maintenance flow events would pass to the natural downstream reach during the winter period. In Santa Rosa Creek most of the channel downstream of Spring Lake has been altered for flood control and attenuation of peak flows from storage in Spring Lake does not negatively affect the geomorphology of the creek.

There is no outflow from these reservoirs during the summer so summer water temperatures would not be increased in the downstream reaches of the creeks.

When the instream reservoirs (Matanzas, Brush, and Piner) refill in the rainy season, downstream flows would be reduced. Brush and Piner reservoirs are small and are located fairly high in the watershed, so the effect to downstream habitat is not expected to be significant. Matanzas Creek reservoir has a larger capacity and affects a larger drainage area. It generally begins to spill in mid-December, so flows during the first half of the coho upstream migration period (November through January) and the early portion of the coho salmon spawning season (December through mid-February) may be affected. This affects half of the upstream migration period and the early portion (20 percent) of the coho salmon spawning season. Therefore, the risk to the population is low.

Sediment and large woody debris retention on Brush Creek, Piner Reservoir, and the diversion on Spring Creek are low because these facilities are small, so effects to downstream habitat would likely be minimal. The sediments removed from the Spring Lake diversion on Santa Rosa Creek usually contain finer rather than coarser sediments, and the diversion of some small amounts of gravel is not likely to affect the availability of spawning habitat in this reach of Santa Rosa Creek. Large woody debris is only rarely trapped in Spring Lake, and if it is removed, it is likely to be used in revetment work elsewhere. Large woody debris has not been removed from Matanzas Creek Reservoir in the past so it appears that it is generally not recruited there.

The capacity of Matanzas Creek Reservoir is larger, so retention of spawning gravel in the reservoir may affect downstream spawning habitat. Spawning habitat is also limited by other issues related to the geomorphology of the channel. Portions of Matanzas Creek (downstream of E Street) have been channelized and levied, which reduces the habitat value of these reaches. A 1997 CDFG stream inventory survey conducted upstream of E Street (CDFG 2001a) indicated that the best spawning habitat exists in the lower portion of Matanzas Creek, but sediment transported downstream in the winter impacts potentially good-quality spawning gravel. Little riffle habitat for spawning was found, and what does exist was unsuitable due to high gravel embeddedness. The CDFG report concluded that measures to reduce fine sediment input should be implemented, but did not cite lack of spawning gravel as an issue. Therefore, while some spawning gravel may be retained in the reservoir, the risk to the populations of listed fish species from gravel retention is low.

Spring Lake is a large, shallow lake that provides habitat for warmwater fish species that prey on salmonids. Largemouth bass and crappie have been caught during fish rescues conducted in Spring Lake (S. Chase, SCWA, pers. comm. 2003a). When Spring Lake is dewatered for maintenance, a screen prevents the release of predators from the lake to Santa Rosa Creek. Piscivorous fish could escape from Spring Lake by traveling through the stand pipe that drains when the lake elevation becomes high during storm-flow events. Escapees from Spring Lake may contribute to the local population of predators in downstream areas. Populations of largemouth bass are already established in the Russian River and possibly in the Laguna de Santa Rosa, so introduction of largemouth bass from Spring Lake would not introduce a new risk to Santa Rosa Creek. However, habitat in

Santa Rosa Creek is not generally favorable for largemouth bass (S. Chase, SCWA, pers. comm. 2003a).

Data collected in 1999 in Santa Rosa Creek a short distance upstream of Spring Lake indicate that this reach of Santa Rosa has cool summer water temperatures (mean monthly temperatures of 15.7ºC to 17.5ºC in June through September) (SCWA 1999d). Mean monthly water temperatures in Santa Rosa Creek further downstream of the reservoir (near the US 101 Bridge) were only about 1ºC higher. These data indicate that summer water temperatures in these reaches are likely to favor salmonids over the warmwater fish community.

A small, chlorinated swimming lagoon is drained or pumped to Spring Lake when the swimming season is over. However, chlorine dissipates as it passes through the water cannon in the lagoon and would be diluted once the water enters Spring Lake. Therefore, chlorine levels in water discharged from Spring Lake would be very low.

The most significant effect of the flood control reservoirs would continue to be entrapment of anadromous salmonids into Spring Lake. Storm events with flows high enough to flow to Spring Lake generally occur in January and February, but after March storm events this high are less frequent. Juvenile steelhead or coho salmon could be trapped during outmigration (February through mid-May). Because good quality spawning and rearing habitat occurs upstream of the diversion, it is expected that some coho salmon and steelhead may be trapped. Fish sampling in Santa Rosa Creek (Cook and Manning 2002) found no coho salmon, so currently the risk to coho salmon is very low. The study documented the presence of steelhead in reaches near Spring Lake and in the headwaters. The predominant age class was young-of-the-year, with a few older fish present. Age 1 and older fish are smolt-sized and most likely to move downstream during high flows. Although fry may also be carried downstream during high flow events, fry emergence does not begin until March. Furthermore, fry that are displaced so early in the incubation and emergence period are susceptible to mortality due to high flows. Therefore fry are far less likely to be entrained into Spring Lake.

Only about one storm event in a year would be high enough for water to spill to Spring Lake, for a few days in most years, and chances are that many of these events would occur prior to the steelhead downstream migration period. The risk to the population of steelhead is low because only a fraction of the smolt-sized fish that would migrate during a single storm would be affected, only one storm per year results in flows high enough to divert to Spring Lake, and the overlap between the juvenile salmonid migration period and the period of time water is most likely to spill to Spring Lake is not long.

5.4.2.5 Bank Stabilization in Central Sonoma Watershed Project and Mark West Creek Watershed

Maintenance activities are performed on levees and bank stabilization structures on waterways in the Santa Rosa urban area. Maintenance of riprap is often needed in various channels in the Mark West Creek watershed (B. Oller, SCWA, pers. comm. 2000). A channel alignment project was completed at the confluence of Hinebaugh and Wilfred creeks. This was an old flood control project and this kind of project is not planned for the future. When riprap is repaired, Methods 5, 6, and/or 7 may be used. Sediment containment evaluation scores for these methods are given in Table 5-45 (see description of methods in Section 5.4.3.1). Opportunity for injury evaluation scores are given in Table 5-46.

The work area would be isolated with a barrier when it affects a wetted portion of the stream to minimize direct injury to fish. Effective sediment control BMPs would be employed to limit input of sediment from work on streambanks and instream work. Because the work would be generally performed on eroding banks, this bank stabilization measure would likely to decrease sediment input to the stream and would not have large effects on existing native riparian vegetation. However, hard-armoring techniques such as riprap can prevent the establishment of a native riparian corridor over the long term, reducing benefits to salmonid habitat, like riparian cover and cooler water temperatures. SCWA has developed a set of BMPs and other guidelines to limit the amount of hard-armoring in natural waterways associated with bank stabilization work. These guidelines give priority to the use of bioengineering and revegetation whenever feasible to prevent the loss of riparian habitat and to protect aquatic habitat for listed species.

Table 5-45 Sediment Containment Evaluation Scores for Bank Stabilization and Structure Maintenance and Repair Practices

Category Score	Evaluation Category	Method Score
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	9,10,12,16
4	Clean bypass or similar method used.	15
3	Effective instream sediment control (e.g., berm/fence).	5,6,7,8,11
2	Limited sediment control.	
1	No instream sediment control.	
	Component 2: Upslope Sediment Control	
5	No upslope disturbance, or an increase in upslope stability.	5,6,7,10, 11,16
4	Limited disturbance with effective erosion control measures.	9,12,15
3	Moderate to high level of disturbance with effective erosion control measures.	8
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel or major changes in channel morphology.	

Table 5-46 Opportunity for Injury Evaluation Scores for Bank Stabilization and Structure Maintenance and Repair Practices

Category Score	Evaluation Category	Method Score
5	Project area is above the high-flow WSE defined by the 1.5-year bankfull event and/or above the tops of bars, and requires no isolation from flow.	7,10,16
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	12
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	
2	Limited ability to apply appropriate BMPs.	5,6,8,11,15
1	Appropriate BMPs are not applied.	

5.4.3 Bank Stabilization in the Russian River and Dry Creek

Channel improvements were built to control streambank erosion after the Warm Springs Dam Project and Coyote Valley Dam Project regulated flows in Dry Creek and the upper mainstem Russian River. The USACE inspects these sites and SCWA and the MCRRFCD maintain them in Sonoma and Mendocino counties, respectively. SCWA and MCRRFCD also inspect non-project levees (Public Law 84-99 sites) and property owners are informed of needed repairs.

USACE guidelines for the maintenance activities downstream of Warm Spring and Coyote Valley dams are contained in USACE Flood Control manuals (USACE 1965a, 1965b, 1991). USACE, in coordination with NOAA Fisheries and CDFG, would review the sediment and vegetation control obligations contained in the USACE Flood Control manuals and modify them to minimize the effects of these activities on listed fish species.

This section evaluates effects related to maintenance of channel improvement projects. It also assesses vegetation removal and gravel-bar grading to control bank erosion in the mainstem of the Russian River.

5.4.3.1 Warm Springs and Coyote Valley Dam Projects on Dry Creek and Russian River

Maintenance of Bank Stabilization Structures and Levees

Current bank stabilization activities involve maintenance of these channel structures. No new structures are planned. Several types of bank stabilization projects were implemented on Dry Creek and the Russian River:

- Anchored steel jacks
- Flexible fence training structures
- Wire mesh and gravel revetments

- Pervious erosion check dams
- Rock bank
- Board fencing
- Erosion control sills
- Concrete weir

Some structures have been covered with soil, have well-established vegetation, and, therefore, do not require maintenance beyond inspections. If, during annual inspections, the USACE finds erosion that could undermine levees, SCWA makes repairs. Two types of maintenance activities are performed: 1) bank repair (earth banks) and 2) structure maintenance/repair.

Methods

Standardized maintenance methods and BMPs have been developed in conjunction with the Bay Area Storm Water Management Agencies Association (BASMAA) to minimize negative environmental effects (SCWA 1996b). (Method numbers not discussed in this section apply to sediment and debris removal and to vegetation control.)

Method 5: A dump truck, or excavator with an extended arm, is used to repair rock riprap or place rock in areas of slope undercutting, scour hole or bank slope erosion. Rock is dumped directly on the bank from a dump truck. If the face of the slope has eroded, the excavator digs a 2- to 3-foot-deep trench at the toe of the bank for the width of the eroded area. The excavating equipment places 2 to 3 feet of rock into the toe, and rock riprap is placed up the bank from the toe. Smaller rock may be dumped to fill voids in the larger riprap.

Method 6 is used to repair large and long erosion areas. In addition to activities in Method 5, the excavating equipment may fill the area farthest from the channel slope with native soil or road-base shale and then compact the area. Rock riprap is placed up the band from the toe. Smaller rock may be dumped to fill the voids.

Method 7: Erosion areas around culverts are repaired by excavating the trench containing the culvert with excavating equipment, dumping sand, or native soil on the bank, and then using the excavating equipment to place the material into the trench. Portable compactors compact the fill. Six inches of road base is dumped into the excavated area and compacted using a roller/compactor.

Method 8: Shaping may be done in constructed channels, but not on natural waterways. A dozer with a blade is used to align flow direction of the creek or channel and to protect banks or restore erosion damage. The dozer is operated across or up and down the bank, using the blade and tracks to compact the soil.

Method 9: Dirt or rock access roads are repaired by dumping dirt or rock from a dump truck over the areas of road, spreading the material with a grader, and using a roller/compactor to compact the surface.

Method 10: Undercut pipe outfalls are repaired by replacing rock in scour holes below the pipe and reshaping the channel to direct flows away from the affected areas. If the erosion is deep, Method 6 is applied.

Method 11: Grouted rock is repaired by clearing the area of broken or damaged material with an excavator with an extended arm or a backhoe operated from the service road. Bank disturbance is kept to a minimum because equipment is not operated on the bank. Deeply eroded areas are repaired if necessary with Method 6. Rock riprap is placed on the bank of the stream channel bottom with Method 5 and grouted with ready-mix concrete from a shoot or a concrete pumper.

Method 12: Minor underlining of a lined channel is repaired by accessing the area behind the lining from the top of the bank using hand tools or a backhoe to open a small access. A concrete/sand slurry ready mix would be distributed using a shoot or a concrete pumper.

Method 13: Major undermining repair would be contracted out. Historically, significant undermining has not occurred.

Method 15: When drop structures or check dams are repaired, water is diverted around the affected area. Isolation from flow would minimize sediment input and direct injury to fish. If the diversion is large, a dozer with a blade brings in or moves on-site material for construction of a berm or diversion dam.

Method 16: Three to four person crews repair chainlink, field and barbed wire fences, and pipe stepover and smaller swing gates. Fence parts, whole fences or gates may be repaired or replaced. The equipment used may include hand tools, welder, fence stretcher, winch etc. Smaller pipe stepover and swing gates are fabricated on-site or at SCWA's shop.

These practices and their potential effects on listed species and their habitat were more fully evaluated in *Interim Report 5: Channel Maintenance* (ENTRIX, Inc. 2001b). Each method was evaluated for direct effects on critical habitat or injury to fish during the maintenance activities (Table 5-45 and 5-46).

In general, the greatest potential, direct, short-term effects to fish or their habitat could occur from repair of eroded banks (Methods 5 and 6), and shaping of constructed channels (Method 8), particularly if work is done near the toe of the channel. Because a barrier would be used to control potential downstream sedimentation, a score of 3 is applied for these methods (Table 5-45). No bypass or fish rescue/escape would be provided, so there is a potential for injury to fish, as reflected by a score of 2 in Table 5-46. However, heavy equipment would not generally be operated in the streambed, so the overall risk is low. Other methods may have potential, localized direct effects that are smaller in scale.

Long-term effects from these projects may include decreased erosion when banks or landslides are stabilized. Instream cover may increase if rocks fall into the stream. The extent of these effects depends on how much work is required in the streams or river, and are discussed in the following sections. The extent of these effects also depends on the condition of the riparian corridor and the streambed, because poor habitat conditions may be improved.

Warm Springs Dam Channel Improvement Sites (Dry Creek)

SCWA maintains 15 federal sites in Dry Creek. One nonfederal site in Dry Creek is inspected by SCWA. To ensure the flood control works remain eligible for rehabilitation under Public Law 84-99, a nonfederal project must meet the minimum USACE requirements before any request for assistance can be provided. It is required that the work be performed prior to the flood season or within 6 months of the inspections.

A biennial post-flood season inspection of the Dry Creek Channel Improvement Project was conducted on July 26-27, 1999 by the USACE. Table 5-47 provides information about the 15 bank stabilization structures (federal sites) located on Dry Creek, as noted in the 1999 USACE inspection. Rock bank structures are usually located on one bank. The 1999 USACE inspection of the 15 federal sites gives an idea of the amount and type of work that is generally needed.

It was noted that in all bank protection sites, vegetation should be trimmed to allow inspection. At the board fence sites, large trees and other vegetation would begin to damage the fence if not trimmed or removed, and large trees and other vegetation are beginning to choke the channel. Tree removal and regrouting were recommended for concrete sills. Tree trimming and/or removal at the board fence sites would reduce the amount of woody debris that may otherwise have been available in sites 3, 8, and 12.

Table 5-47 Channel Improvement Sites on Dry Creek

Site	Type	Length (ft)	Summary of Comments on Repairs needed
1	Rock Bank	600	Heavy vegetation prevented close inspection, but probably helps hold toe in place. No apparent scour.
2	Rock Bank	750	Heavy vegetation above the toe should be trimmed to allow inspection.
3	Board Fence	700	Some fallen trees in the creek should be cleared. Large trees will begin to damage the fence if not trimmed or removed. Fence and posts still in good condition.
4	Rock Bank	200	Only upper rock is accessible. Vegetation needs to be trimmed or removed above toe of rock.
5	Concrete Weir		Good condition.
6	Rock Bank	450	Weir in good condition. Trees in the channel have been trimmed. The downstream grouted rock is undercut. The channel between the weirs is steep and eroded, and further bank protection should be considered.
7	Board Fence	900	Only the upper rock is accessible due to heavy vegetation.
8	Rock Bank	480	No land access is available. Large trees are falling and should be cut before the fence is damaged.
9	Concrete Weir		Site in good condition. Heavy brush on the right side of the channel should be cleared or trimmed to maintain the channel capacity.

Table 5-47 Channel Improvement Sites on Dry Creek (Continued)

Site	Type	Length (ft)	Summary of Comments on Repairs needed
10	½ Rock Sill and Bank		Sill is probably buried and the rock protection in good condition. Dirt has apparently been moved over the sill apron by the landowner, making it very hard to locate.
11	Rock Bank	200	The rock is in place, mostly covered with low brush.
12	Concrete Sill		There is a large sand bar with large trees in the center of the channel, downstream from the fish ladders. Trees should be removed or trimmed. Grout is wearing out and should be redone. Trash racks need cleaning.
13	Concrete Sill		Driftwood should be removed. Rocks are coming loose from grout, which should be redone.
14	Concrete Sill		Several small boils are coming through the sill, and rocks are coming loose. Needs regrouting to attach rock and fill boil paths.
15	Rock Bank	500	Heavy vegetation should be trimmed above the toe. There is some sediment aggradation in the lower reaches of the project, mainly upstream from the sills.

Grouted areas that need repair would require Method 5. As the channel between weirs at site 6 was steep and eroded, it was recommended that further bank protection should be considered. The largest effects would likely occur where bank protection and undercuts need repair, as in site 6, where Methods 5 or 6 are required (see *Interim Report 5: Channel Maintenance* for a detailed assessment of effects from these practices). Methods 5 and 6 could introduce turbidity and sediment to Dry Creek during work on the toe of the stream channel, but a barrier used during construction would reduce suspended sediment concentrations. There is a small risk of injury to fish because no bypass, rescue, or escape would be provided, but limited, if any, instream work would be required.

No new structures are proposed in Dry Creek. Activities are limited to maintenance of existing structures, and no additional vegetation maintenance is proposed in Dry Creek. Therefore, effects would be generally limited to small-scale effects related to sediment input to the creek and some small amount of vegetation removal. Effective BMPs reduce the risk of short-term effects. Therefore, both short-term, direct effects to fish and long-term habitat effects would be low.

Coyote Valley Dam Channel Improvement Sites (Russian River)

The bank stabilization sites in the federal portions of the Russian River channel improvement project consist primarily of levees, anchored jacks, and riprap banks. Additionally, flexible fencing projects were installed in some places. Table 5-48 is a list of sites that were inspected in September 2000 (USACE 2000). Sites are identified by the river mile location of the downstream end and indicate right or left bank looking downstream. A previous inspection report categorized numerous sites as destroyed, functioning, or buried, and a list of these 21 sites was presented to be reinspected. The amount of work recommended on these sites is fairly typical of what is recommended each year.

Table 5-48 Field Inspection of 21 Sites in the Federal Portion of the Russian River Channel Improvement Project (RM 42.4 to RM 61.3) (September 2000)

Site[1]	Summary of Comments on Repairs needed
42.4R	Heavy vegetation on a stable bank. Some jacks visible. Cable not anchored downstream.
43.5R	Stable bench, with jacks about 1/2 buried in heavy vegetation along a tree line.
46.7R	High exposed bench with some rock protection. Large wooded island in the riverbed. No jacks or fence could be found. Site is buried, hidden in heavy vegetation on the island, or gone.
49.2R	Bank stable, with heavy vegetation. Jacks could not be seen.
50.8R	Jacks probably buried under a stable bench with heavy vegetation.
53.1R	High stable bench, but the only jacks visible appear damaged, separate parts in a ditch.
53.9R	There is a bench and heavy vegetation. Jacks are buried or gone.
54.4R	There is a high bench with heavy vegetation. The site is buried in the bench or gone.
56.5R	The bench has been cleared. Jacks are buried or gone.
57.7R	Jacks are about 2/3 buried on a stable bench. Last year the line was found to be cut for a road access to the river.
61.1R	Bank appears stable. Only rock could be found. Jacks may be under the rock.
46.8L	Stable bank with heavy vegetation. No jacks found.
48.7L	Bank appears stable. Jacks in heavy vegetation at upstream end. No jacks for at least the downstream 300 feet, except for a pile at the downstream end. There is rock protection on the downstream 300 feet.
50.0L	Bank appears stable. Site has jacks below rock protection along much of the bank.
50.3L	Entire bank appears stable. There are some jacks upstream, some buried, some loose. The downstream slope has rock protection.
50.6L	Not a bank stabilization site. Loose jacks noticed on the riverbank.
51.0L	Jacks are in place along a stable bench with a levee on the water side.
51.3L	Bank stabilized by a tree line. Many pieces of jack, cable and rod indicate the jack line has been destroyed and need not be inspected in the future.
52.9L	High bench may conceal the jack line. No jacks found along the bank, one was in the river channel.
57.8L	Downstream jacks are damaged, unburied, and not anchored. The upstream 1/2 of the jack line is in heavy vegetation on a stable bank.
58.9L	Bank looks stable. Some jacks visible downstream, some found further upstream with approximately 2 feet protruding last year. Some are probably missing.
61.3L	Bench looks very stable. Site has a fence upstream and jacks downstream in heavy vegetation. Downstream jacks are at the water line.

[1] "R" and "L" after the River Mile refer to right or left bank, looking downstream.

Most of these sites are in stable condition and do not require work in the near future. Based on this inspection, the USACE recommended various repairs or replacement of some of these structures. These recommendations are presented in detail in *Interim Report 5: Channel Maintenance.* The USACE also recommended that a vegetation management program be implemented to reduce blockage of the river channel and increase access for maintenance and inspection of the banks, and that all loose, nonfunctional jacks be removed from the project reaches.

Because most of these sites are in stable condition, it is not expected that there would be substantial short-term or long-term effects from maintenance of these sites. However, in combination, the federal and nonfederal obligations to maintain levees and bank erosion control structures on the Russian River could have a substantial habitat altering effect.

This effect would be primarily related to a reduction in the extent of riparian corridor by tree removal, trimming, and placing riprap on streambanks. This would reduce available shading and cover. Benefits related to reduced sediment input due to reduction of streambank erosion are also likely to occur.

Nonfederal Portion of the Russian River Channel Improvement Project

The USACE, SCWA, and MCRRFCD would continue to inspect nonfederal channel improvement projects related to Public Law 84-99 in the Russian River and one levee in Dry Creek. If repairs were needed, the property owner and USACE would be notified, and the property owner would be responsible for needed repairs. The effects of channel maintenance activities for nonfederal projects are evaluated as interdependent effects in Section 7.

5.4.3.2 Gravel Bar Grading and Vegetation Maintenance for Bank Stabilization in the Russian River

In the mainstem Russian River, gravel bar grading and vegetation maintenance would continue to be conducted by two different agencies, the MCRRFCD and SCWA, each in their respective counties, to control bank erosion.

Sediment maintenance work would consist of grading gravel bars and creating overflow channels during the dry summer season. This activity would be linked to vegetation maintenance practices. Sediments would be redistributed in the channel primarily to create overflow channels through existing bars to direct water flow during high flow events and to prevent bank erosion. Vegetation removal would be more limited in scope than for baseline conditions.

SCWA would maintain over a 22-mile reach between RM 41 near Cloverdale to RM 63, near the Mendocino County line. MCRRFCD also would continue to excavate and grade sediments at targeted sites in over a 36-mile reach of the Russian River. MCRRFCD would survey one-third of the 36-mile reach (12 miles) annually. Site-specific areas where maintenance is needed would be identified for work implementation. CDFG staff would continue to participate in site visits and consult on site selection. Two or three areas with potential for “blowouts” of streambeds or banks may be worked on annually in each county, with a maximum of four sites in a year per county. These sites selected for maintenance work generally range in size from 10 to 300 feet in length.

Gravel Bar Grading

Potential effects of gravel bar grading operations could include direct injury to fish and immediate, direct effects to habitat. Indirect effects to habitat could include an increase in sediment to the stream and long-term alterations to migration, and spawning and rearing habitat.

Direct Effects to Fish

Gravel bar grading and sediment removal activities have the potential to injure or kill fish. However, because work would be conducted on gravel bars during the dry season and away from the wetted channel, there would not likely be a risk of direct effects on fish. The work would be conducted between July 1 and October 1 to avoid spawning and incubation periods. The only species/life-history stage that may be present on the Russian River during gravel bar grading or vegetation removal work is rearing juvenile steelhead (low-flow summer period).

SCWA and MCRRFCD biologists assess habitat conditions prior to sediment removal to ensure that listed fish species are not likely to be in the maintenance area. Because work would be conducted outside and away from the wetted channel, the work requires no isolation from flow and the score is 4 (Table 5-49).

Work would take place on dry gravel bars during the low-flow season, and would not require re-routing streamflow in the low-flow channel. Therefore score of 4 was given for instream sediment containment (Table 5-50). Easy access to the site from existing service roads at the top of bank may not be possible along the Russian River, and occasionally access roads may have to be installed. However, SCWA and MCRRFCD employ upslope sediment control measures such as silt fences when performing the work, so a score of 3 is given, indicating a moderate- to high-level of disturbance with effective erosion control measures.

Table 5-49 Opportunity for Injury Evaluation Scores for Gravel Bar Grading in the Russian River

Category Score	Evaluation Category	Current Operations Score*
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or above the tops of bars, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	St
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

*St = steelhead

Table 5-50 Sediment Containment Evaluation Criteria

Category Score*	Evaluation Category	Current Operations Score*
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	St
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	
2	Limited sediment control.	
1	No instream sediment control.	
	Component 2: Upslope Sediment Control	
5	No upslope disturbance, or an increase in upslope stability.	
4	Limited disturbance with effective erosion control measures.	
3	Moderate to high level of disturbance with effective erosion control measures.	St
2	Action likely to increase sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel, or major changes in channel morphology.	

*St = steelhead

Long-Term Habitat Changes

Gravel bar grading and vegetation removal may result in alterations to salmonid spawning, rearing, and migration habitat. The Upper and Middle Russian River contain steelhead and Chinook salmon migration, spawning and rearing habitat, and coho salmon use the Middle Reach as migration corridors. Alterations to mainstem habitat are most likely to affect Chinook salmon spawning and rearing because the Upper Russian River may contain primary habitat for those life-history stages.

Potential effects include:

- Gravel bar grading and re-alignment in the Russian River is likely to affect the geomorphology of the channel. Vegetation with roots that stabilize the channel may be moved. By preventing stable bar development, the channel becomes straightened and sinuosity decreases. Decreased sinuosity reduces bank erosion, but also reduces the opportunity for pool development by limiting scour on the outside of meander bends. In addition, gravel bar grading generally results in a flatter streambed, reducing the hydraulic diversity and associated aquatic habitat diversity represented in the channel. This lack of hydraulic diversity probably includes reduced availability of high-flow refuge habitat due to limited bedform topography as bars are regularly regraded. In addition, maintenance activities such as re-aligning the river channel to prevent bank erosion may have other consequences, including reducing hydraulic and associated habitat complexity.

- Gravel bar grading is closely interrelated with removal of riparian vegetation growing on the bars. A 25-foot buffer strip would provide shade and cover along the low-flow channel and help protect summer water temperatures.
- Disturbance of sediments within the channel during the low-flow season, as well as removal of vegetation on channel bars, may potentially result in increased mobilization of fine sediments during the high flow season. This could result in sedimentation of spawning gravel and sedimentation of rearing habitat substrates both within the immediate area where work was done and in downstream areas. Sedimentation of aquatic habitat may also affect aquatic insect production that forms the food base for juvenile salmonids. Loss of spawning gravel is not expected to occur because, in general, sediments are not permanently removed from the river. (Spawning gravel removed from the Lower Russian River may be relocated to Dry Creek where potential spawning activity may be higher.)

Scoring criteria consistent with NOAA Fisheries guidelines for sediment removal (NOAA Fisheries 2003b), are applied for the height of sediment to be removed from gravel bars. Most bars along the river are greater than 3 feet in height above the low-flow water surface elevation. By reducing the bar height to 1.5 feet above the low-flow water surface, a bar that begins with a total height of 3 feet would thereby be reduced by 50 percent. Bars taller than 3 feet would be reduced by greater than 50 percent, assuming that they are graded to a final elevation of 1.5 feet above the low-flow water surface. Therefore, scores would range between 1 and 2, indicating that this work would degrade fish habitat (Table 5-51).

Table 5-51 Evaluation for Gravel Bar Grading in the Russian River

Category Score	Evaluation Category	Current Operations Score*
5	No sediment removal or grading.	
4	<25% of the bar height is removed.	
3	25% to 50% of the bar height is removed.	
2	>50% to 75% of the bar height is removed.	Co, St, Ch
1	>75% of the bar height is removed.	Co, St, Ch

Co = coho salmon, St = steelhead, Ch = Chinook salmon

Under the proposed project, the scope of work would be more limited than under baseline conditions. No more than four bars in each county (four in Sonoma County and four in Mendocino County) would receive maintenance in any one year. The length of any one site would not exceed approximately 1,000 feet, or a single bar length. The areas that would receive gravel bar grading and vegetation maintenance would be scheduled so that bars are worked on in rotation over a course of 3 to 5 years. This way, some bars would always provide high-flow velocity refuge areas for salmonids (river meanders, pools, and vegetation) in any given year. Protocols would be implemented to preserve a buffer zone, grade the channel to minimize the risk of stranding fish during flow recessions, and preserve large woody debris. Although habitat would be altered at any one site in a year, the limitations under the proposed project are designed to ensure that sufficient, good-quality habitat remains in the mainstem over time.

Vegetation Maintenance

On the mainstem Russian River, SCWA vegetation maintenance would extend from approximately RM 41 near Cloverdale to RM 63, near the Mendocino County line. Channel clearing would include removal of serious obstructions, including trees, brush, and snags. This work may be done in conjunction with gravel bar grading operations. Evaluation criteria are used to assess the potential effect on salmonids and habitat of various percentages of vegetation removed from the Russian River.

Alternative measures would be pursued where feasible, such as the utilization of bio-engineering practices to stabilize banks, tree planting to add bank stability and reduce understory growth, offset levees to increase floodplain, or floodplain level culverts to increase floodplain draining at culvert crossings.

Selective vegetation removal by hand limits streambed and streambank disturbance. When vegetation is removed from the stream channel bottom, there is a reduction in the amount of cover available in the stream and a loss of winter high flow refugia. Therefore, this practice would be restricted to when there is an unacceptable threat from a 100-year flood event or where a decrease in bank stabilization threatens a manmade structure. Native trees growing along streambanks have been allowed to become established and this has increased riparian corridor width. This practice would continue.

No recent estimate of vegetation removal requirements have been made by SCWA for the Russian River; however, previous maintenance included removal of vegetation from approximately a 250-foot- to 400-foot-wide section of channel (B. Oller, SCWA, pers. comm. 2000). On the mainstem Russian River in the Alexander Valley, channel widths generally range from approximately 200 feet to 800 feet. Upstream of Alexander Valley, channel widths are narrower, approximately 200 feet to 500 feet. Given the need to remove vegetation from an estimated 250-foot to 400-foot width of the Russian River, this would result in loss of 40 percent to 100 percent of the riparian vegetation within the channel at locations where the vegetation maintenance occurs. Because steelhead and Chinook salmon rearing and spawning may occur in the mainstem, the score is 1 for these species (Table 5-52).

In Mendocino County, maintenance work consists of removing willows, grading bars, and creating overflow channels, primarily to reduce the potential for streambank erosion during high flows. It is estimated that more than 50 percent of the vegetation in the channel cross sectional area is typically removed and/or re-distributed against the streambank. This practice would continue. Therefore, the score for MCRRFCD maintenance practices is a 1 (Table 5-52). Up to four sites may be regularly maintained.

Table 5-52 Vegetation Control Scores for the Russian River — Sonoma and Mendocino Counties

Category Score	Evaluation Criteria Category	Score
5	No vegetation removal except "spot" treatment, or removal of only non-native species.	
4	<10% removal.	
3	>10% to <25% reduction in vegetation.	
2	>25% to <50% reduction in vegetation.	
1	>50% reduction in vegetation.	St, Ch

*St = Steelhead, Ch = Chinook salmon

Vegetation removal, combined with gravel bar grading, has the potential to result in habitat alterations, including changes in channel geomorphology and sedimentation of aquatic habitat. The removal of riparian vegetation on bars likely reduces the availability of high-flow refugia and generally decreases hydraulic and associated aquatic habitat diversity, and it may take years for vegetation to reestablish. In addition, bar accretion is minimized when velocity-retarding vegetation is removed, thereby reducing sites available for sediment deposition and storage. Inhibiting bar development most likely results in reduced channel sinuosity. This change in channel geomorphology tends to reduce the formation of pools and also contributes to the overall lack of hydraulic and aquatic habitat diversity.

SMI stream habitat typing data show summer habitat conditions throughout the Alexander Valley are typical of a simplified channel (Jensen and Halligan 1999, cited in NMFS 2002). There are low shelter ratings, low occurrence of backwater habitats, low values of vegetated area on banks, and other indications of poor velocity refuge conditions. Therefore, further loss of these shelter components with the proposed project may contribute to further degradation of habitat in portions of the mainstem.

Sediments disturbed during the low-flow season may be mobilized at the onset of the rainy season. Mobilization of fine sediments from the streambed over substantial lengths of the Russian River could collectively have an effect on steelhead and Chinook spawning and rearing habitat. Because the first flows of the rainy season are most likely to mobilize recently disturbed sediments, the effect is likely to be greatest for Chinook because they spawn occurs earlier and egg incubation occurs over a longer period of time.

Vegetation removal for bank erosion control has the potential to cumulatively result in substantial habitat alterations. Protocols would be implemented under the proposed project to reduce the cumulative effects of the work. The work would be limited so that vegetation would only be removed if necessary to protect against severe bank erosion, or to protect levees, infrastructure, or private property. Buffer zones would be maintained to protect the existing thalweg of the channel. Vegetation removal would be scheduled so that bars are worked on in rotation, thereby leaving some bars that would always have willows that provide high-flow refuge areas for salmonids. Although effects to salmonid habitat would be expected to occur, the limitations under the proposed project would be implemented to ensure that sufficient habitat remains for listed fish species.

Synthesis of Effects of Gravel Bar Grading and Vegetation Maintenance for Streambank Stabilization

Immediate, direct effects to fish and sedimentation to aquatic habitat are likely to be minimal or nonexistent. The work would be scheduled to avoid spawning an incubation periods. Steelhead may rear in the mainstem during the summer, particularly in the upper mainstem, but are not likely to be substantially affected by the work.

Gravel bar grading and vegetation maintenance could have long-term effects to salmonid habitat. Coho salmon utilize the mainstem primarily as a migration corridor, and steelhead and Chinook salmon utilize the mainstem for spawning, rearing, and migration.

In the past, much of the mainstem of the Russian River has received periodic maintenance, and the potential to substantially alter habitat was great. Under the proposed project, these activities would be limited. No more than four bars in each county (four in Sonoma County and four in Mendocino County) would receive maintenance in any one year and the length of any one site would be limited. Gravel bar grading and vegetation removal would be scheduled in rotation so that high-flow velocity refuge areas for salmonids (river meanders, pools, and vegetation) would be maintained. Protocols would be implemented to preserve a buffer zone, minimize the risk of stranding fish during flow recessions, and preserve large woody debris. Although habitat would be altered at any one site on a 3- to 5-year rotation, the proposed project would ensure that sufficient, good quality habitat would remain in the mainstem over time.

Sites along the mainstem Russian River where frequent and/or extensive maintenance are required to prevent bank erosion would be identified. These areas would be assessed as candidates for bank stabilization projects. Implementation of these projects would be coordinated with NOAA Fisheries. Bioengineered structures would be used whenever possible and sites would be limited to not more than 1,000 feet of channel to avoid large segments of continuous hard-armoring from cumulatively developing. This may reduce the need for future gravel bar grading and vegetation maintenance within a site and preserve instream habitat features. However, the benefits would be weighed against the risk that future streambank erosion problems may appear upstream or downstream of the site. Therefore, depending on site-specific factors, it may be preferable to continue implementation of gravel bar grading on a regular basis.

5.4.4 Emergency Bank Stabilization in Natural Waterways

5.4.4.1 Sediment Maintenance in Natural Waterways

SCWA does not perform routine sediment removal activities in natural waterways. However, emergency sediment removal and bank stabilization work is occasionally required in natural waterways after a large storm event. These instances are usually brought to the attention of SCWA, when landowners request SCWA to remediate problems associated with reduced channel flood capacity. In the past, sediment excavation in natural waterways has almost always been related to landslides, bank failure, or erosion. This activity would continue.

It is estimated, based on past activities, that sediment removal in natural waterways would occur about once every 10 years (B. Oller, SCWA, pers. comm. 2000). The most recent sediment removal project in a natural channel occurred on Big Sulphur Creek in 1997. However, remedial sediment removal in natural waterways could be needed on almost any stream in the Russian River basin following storm events. Listed fish species may or may not be present in the stream where the work may be required. Habitat conditions may also be highly variable in these natural streams. Some standard BMPs would be applied to work in natural waterways. If possible, sediment excavation and bank stabilization would be performed when the stream is experiencing low-flow conditions; generally during the summer or fall months. Depending on the location, there may or may not be flow in the channel at the time of the sediment removal work. If the channel is not dry, then flows would be diverted, typically using earthen coffer dams, pea gravel or, if necessary, a clean bypass. A fish biologist would inspect the reach where dewatering must occur to allow in-channel work. Fish rescue would be provided, if necessary. Work would be performed using backhoes, excavators, and dump trucks, depending upon the site configuration and available access. BMPs for operating equipment in or near an active stream channel would be followed.

Direct Injury to Fish

Evaluation for sediment containment and opportunity for injury is presented in Tables 5-53 and 5-54. Since listed salmonid species may be present on a given stream at the time of the sediment excavation work, the scoring is applied to all three listed species. The scoring results are similar to that for the flood control channels, except that a score of 3 is given to the upslope sediment control component. Unlike the flood control channels, easy access to the site from existing service roads at the top of bank may not be available on a natural channel. However, SCWA would continue to employs upslope sediment control measures such as silt fences when performing sediment excavation work, so a score of 3 indicating a moderate to high level of disturbance with effective erosion control measures is given.

Table 5-53 Sediment Containment Evaluation Scores for Sediment Removal in Natural Waterways

Category Score	Evaluation Category	Current Operations Score*
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	Co, St, Ch
2	Limited sediment control.	
1	No instream sediment control.	

Table 5-53 Sediment Containment Evaluation Scores for Sediment Removal in Natural Waterways (Continued)

Category Score	Evaluation Category	Current Operations Score*
	Component 2: Upslope Sediment Control	
5	No upslope disturbance, or an increase in upslope stability.	
4	Limited disturbance with effective erosion control measures.	
3	Moderate to high level of disturbance with effective erosion control measures.	Co, St, Ch
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel or major changes in channel morphology.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Table 5-54 Opportunity for Injury Evaluation Scores for Sediment Removal in Natural Waterways

Category Score	Evaluation Category	Current Operations Score*
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or above the tops of gravel bars and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	Co, St, Ch
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Sediment removal and channel clearing activities have the potential to injure or kill fish. Fish that are temporarily displaced may be subjected to stress, increased competition or predation. SCWA biologists assess habitat conditions prior to sediment removal to ensure that listed fish species are not likely to be in the maintenance area. If listed salmonids are determined to be present, a barrier would be established to exclude fish from the area. Fish rescues would be performed, if necessary. Therefore, sediment removal activities and their potential to injure fish in natural stream channels receive a score of 3 (Table 5-54).

Long-Term Changes to Critical Habitat Associated with Sediment Removal and Bank Stabilization in Natural Waterways

Sediment removal activities in natural waterways occur on a very limited and infrequent basis. All past sediment removal activities were associated with large landslides or storm events that delivered large amounts of sediment to the channel. Sediment deposited in the channel reduces flood capacity and may damage infrastructure such as roads, bridges, homes, utilities, etc. The extent of sediment removal varies depending on the amount of sediment deposited in the channel and other channel characteristics at the site. For example, on Big Sulphur Creek in 1997, approximately 1,000 feet of channel was excavated and bank stabilization work was performed.

SCWA would continue to implement BMPs and other guidelines for planning and implementing sediment removal and bank stabilization work performed in natural waterways to protect listed species and to minimize the potential for significant habitat alterations.

Potential habitat altering effects that may occur due to sediment removal in natural waterways include loss of shade canopy and cover, and loss of hydraulic and associated habitat diversity. The potential for habitat-altering effects due to sediment maintenance and bank stabilization in natural waterways to populations of coho salmon, steelhead, and Chinook salmon is small. This is due to the infrequent need for maintenance activities in natural waterways, the prescriptions for limiting the size of any project to 1,000 feet, and the guidelines for incorporating bio-engineering, revegetation, and fish habitat elements into bank stabilization work.

5.4.5 Gravel Bar Grading in the Mirabel/Wohler Area

SCWA augments infiltration capacity for its water distribution system in the Mirabel and Wohler area by periodically scraping gravel bars in the river in the area of diversion to increase infiltration in the river. BMPs would be implemented to control sediment input and turbidity in the river (see Section 4.4.5). SCWA biologists would inspect the gravel bars prior to the maintenance activity to evaluate the need for silt fences and to identify environmentally sensitive areas. Furthermore, permanent vegetation would not removed.

5.4.5.1 Effects of Scraping Mirabel and Wohler Gravel Bars on Critical Habitat and Fish

Gravel bar grading operations have the potential to affect listed species directly through disturbance, injury, or degradation of habitat. Indirect effects can be related to sediment input into the stream and increased turbidity. The following evaluation of risk to fish related to scraping of gravel bars includes: 1) opportunity for direct injury to fish during gravel bar scraping activities, 2) critical habitat degradation from sediment input to the stream, and 3) opportunity for habitat disturbance and/or injury related to the magnitude of the activity. Potential effects to the geomorphology of the river channel are also discussed.

Although some salmonid spawning has been documented by SCWA biologists in this section of the Russian River, primary spawning habitat is not located here. Rearing may occur in the winter and spring, but summer water temperatures are too high in some years to support steelhead rearing. Gravel bar grading operations at the Mirabel Bar do not normally occur during peak spawning migrations, but may occur during juvenile outmigration. At the upstream sites, the opportunity for injury to migrating juvenile salmonids due to scraping activities is minimal, since scraping occurs outside of the wetted channel.

At the Mirabel Bar, gravel is scraped to a low level, creating a depression in which fish may become trapped. The gravel scraping activity normally occurs after the coho and Chinook salmon outmigration periods, although in some years it may occur during the later portion of the outmigration. There is a greater risk to steelhead juveniles, which are more likely to be present during gravel bar scraping activities. Fish rescue is provided for fish trapped at the Mirabel Bar. Fish rescues on June 24 and July 29, 1999 resulted in the capture of 797 fish, although none of the fish were salmonids. No salmonids were captured during fish sampling in September at the Mirabel Bar.

Table 5-55 provides current operations scores for the gravel scraping operations in relation to opportunity for injury at the gravel bars. The scores for the Wohler, Bridge, and McMurray bars are 4 because although streambed sediments are disturbed, gravel bar scraping is done outside of the wetted channel. The score at the Mirabel Bar is 3 because although the area is excavated below the low-flow water level, the project area is isolated from the stream, and fish rescue is provided.

Table 5-55 Opportunity for Injury Evaluation Scores for Gravel Bar Grading Upstream of Mirabel

Category Score	Evaluation Category	Current Operations Score
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or above the tops of bars, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	Wohler, Bridge, McMurray
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	Mirabel
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

The gravel bar grading operations upstream of the inflatable dam are limited to areas outside the active low-flow channel. Therefore, no instream sediment control measures are necessary at the Wohler, Bridge, and McMurray bars.

At the Mirabel Bar, gravel is removed to an elevation below the low-flow water surface elevation of the river. Implementation of BMPs would reduce effects to listed fish species. A berm constructed to prevent water from flowing through the area would control sediment and sediment fences would prevent the input of sediment into the river. Disturbance of salmonid habitat would be limited by keeping operation of equipment to a minimum and heavy equipment activity in the active stream channel limited to moving equipment to and from the mid-channel gravel bars. The sediment removed from the streambeds (spoils at the Wohler and Mirabel areas) would be stored outside of the floodplain, so they would not contribute to sedimentation of downstream habitat.

Turbidity was monitored in 1999 during the gravel bar grading operation at the Mirabel Bar. Background turbidity levels above the bar measured 3.4 NTUs. During construction activities, the upstream and downstream ends of the gravel bar were closed from the river. The highest peak of turbidity was 4.2 NTUs and this event lasted less than 30 minutes. When the grading operation was completed, the outflow channel from the Mirabel Bar was breached at the downstream end of the gravel bar. Turbidity levels reached 37.6 (2 hours after breaching), but levels had declined to 7.3 NTUs after 3.5 hours, and 4.3 NTUs after 5.75 hours. While this turbidity spike was significant, the event was short and would not be expected to have had a significant effect on juvenile salmonids.

Because gravel bar scraping operations occur during a limited time, and BMPs are in place to minimize sediment input into the river, it is likely that gravel bar grading operations would have only very limited, short-term effects on turbidity levels during juvenile rearing or migration. Turbidity is monitored continuously at two sites (upstream and downstream of the bar grading operation) at the Mirabel Bar to determine project-related effects associated with increased turbidity levels.

Sediment control was scored for instream and upslope practices (Table 5-56). The instream component for the Wohler, Bridge, and McMurray bars scored a 5 because the project area is generally dry. Gravel bar grading operations at the Mirabel Bar scored a 3 because the berm generally provides effective instream sediment control. The upslope component was used to evaluate spoils storage. Because spoils are stored away from the channel and operation of equipment on the banks is kept to the minimum necessary, the upslope sediment control score is 4.

The magnitude of the activity is examined at the sites in relation to bankfull widths in the respective areas. The McMurray Bar is approximately 1,000 feet long and 75 feet wide, and the Bridge and Wohler bars are 500 feet long and 100 feet wide (Table 5-57). The Mirabel Bar is approximately 1,000 feet long and 200 feet wide. An estimate of bankfull width from aerial photographs is approximately 200 feet at Wohler and 300 feet at Mirabel.

Table 5-58 estimates the magnitude of the action based on bankfull widths where the gravel bar scraping takes place. There are two components. Lineal distance of the disturbance is rated a 5 for the Mirabel, Wohler, and Bridge bars and 4 for the McMurray bar because the length of the bars is approximately equal to 5 bankfull widths. The width of the activity for Mirabel, Wohler, and Bridge bars is rated as 2 and for McMurray Bar as 3. Scraping at the upstream gravel bars generally occurs outside of the wetted channel and is not as likely to have direct effects. Gravel bar grading in the Mirabel area, based on the moderate size of the wetted area affected, may have a larger effect.

Table 5-56 Sediment Containment Evaluation Scores for Gravel Bar Grading Upstream of Mirabel

Category Score	Evaluation Category	Current Operations Score
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	Wohler, Bridge, McMurray
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	Mirabel
2	Limited sediment control.	
1	No sediment control.	
	Component 2: Upslope Sediment Control (Spoils Storage)	
5	No upslope disturbance, or increase in upslope stability.	
4	Limited disturbance with effective erosion control measures.	Wohler, Bridge, McMurray, Mirabel
3	Moderate to high level of disturbance with effective erosion control measures.	
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion an uncontrolled sediment input to the channel or major changes in channel morphology.	

Table 5-57 Approximate Sizes of Gravel Bars

Gravel Bar	Length	Width	Bankfull Width	Lineal Distance in Bankfull Widths	Width of Activity (Percent of Bankfull Widths)
McMurray	1000	200	75	5	38%
Wohler	500	100	200	2.5	50%
Bridge	500	100	200	2.5	50%
Mirabel	1000	200	300	3.3	67%

Table 5-58 Magnitude of the Action Evaluation Scores for Gravel Bar Grading Upstream of Mirabel

Category Score	Evaluation Category	Current Operations Score
	Component 1: Lineal Distance Estimated in Bankfull Widths	
5	<5 bankfull widths	Mirabel, Wohler, Bridge
4	5-10	McMurray
3	10-20	
2	20-30	
1	> 30	
	Component 2: Activity Width as a Percent of Bankfull Widths	
5	<10 percent of bankfull width	
4	10-25%	
3	25-50%	McMurray
2	50-75%	Mirabel, Wohler, Bridge
1	75-100%	

Gravel removal has the potential to increase stranding of juvenile fish, and to affect the geomorphology of the river channel. When gravel bars are scraped to improve infiltration, the result is a flatter streambed. Improper grading of streambanks could create large, flat, shallow areas along the stream margin or large depressions along the stream margin that become dewatered at low flows. Juvenile fish that take refuge in these areas can be stranded when these areas become dewatered at low flows. After gravel bar grading operations are completed, SCWA contours gravel bars to an approximately 2 percent grade to reduce the potential for stranding.

Given the characteristics of the river in the area, gravel bar scraping activities are not likely to significantly change the geomorphology of the channel and therefore habitat types are not likely to be different. The two-mile reach above the inflatable dam was surveyed to determine whether the impoundment altered the habitat type (SCWA 2000b). This reach is generally run-habitat when the dam is not inflated and primarily pool habitat when the dam is inflated. Aerial photographs and brief field reconnaissance in the area in late 1999 indicate a single-channel river that has a relatively straight trajectory with long sweeping oxbow characteristics through the area. It appears to have relatively few structural features that would create low areas outside of the main channel. The slopes of the river margins are relatively low gradient, but are sloped to the main channel. Bank stability has not been affected by gravel bar grading activities.

When gravel bars are graded, streambed sediments are disturbed. During the first flush of the rainy season, loose sediments may be mobilized and increase turbidity levels. These are likely to be short-term effects. Because these gravel bars are located in the lower river, these sediments are not likely to be deposited in primary spawning or rearing habitat. Therefore, effects to habitat are likely to be low.

In summary, the risk to migrating juvenile salmonids from gravel bar scraping activities related to potential injury to fish (type of operation and magnitude of activity) is none at the Wohler, Bridge, and McMurray bars (upstream of the inflatable dam) and low risk at the Mirabel area operation. Since work at the upstream gravel bars is done outside of the wetted channel, it is not expected that fish would be trapped, or that there would be additional sediment input to the river. The potential to injure juvenile steelhead at Mirabel is greater than at the upstream bars because there is a possibility steelhead may be trapped in the Mirabel Bar. Fish rescues reduce the risk. Gravel bar grading at the Mirabel Bar normally occurs later in the summer, and during fish rescues in the 1999 portion of the monitoring study, no salmonids were found.

The potential risk to juvenile salmonids is greatly reduced for the Mirabel area because the timing of the operation does not normally coincide with migration of the salmonids. The potential to alter habitat with sediment input from instream activities is addressed through implementation of BMPs. The use of BMPs during gravel bar scraping activities reduces the potential for juvenile fish stranding. Spawning does not occur in this area. Effects from gravel bar grading operations are restricted to immediate, short-term effects, including a low risk of entrapment of migrating juveniles and short-term turbidity spikes. Therefore, the overall risk for injury and habitat degradation is low. If additional bars form in the future that may need grading, particularly between Caisson 6 and Caisson 3, the same BMPs would be applied to minimize the risk to salmonids and their habitat.

5.4.6 NPDES Permit Activities

The City of Santa Rosa, County of Sonoma, and SCWA (co-permittees) are co-permittees under an NPDES permit for stormwater discharges from separate municipal storm sewers.

During the years that the first permit was in effect, the co-permittees have determined that the plans and associated activities have been effective. Chemical and biological monitoring results since 1998 indicate that there have been no consistent trends or specific water quality constituents of concern identified (City of Santa Rosa, Sonoma County Water Agency, County of Sonoma 1998, 1999, 2000, and Sonoma, County of, City of Santa Rosa, and Sonoma County Water Agency 20032003). Bioassay results indicate very low toxicity of stormwater from sampled runoff events. Indirect indicators, including number of inspection and enforcement actions, amount of educational materials distributed, and amounts of pollutants removed through maintenance, spill response, and implementation of BMPs, indicate that the SWMP has been successful to-date. NPDES plan activities likely have a beneficial effect on listed species and their habitat.

5.5 Restoration and Conservation Actions

Proposed restoration and conservation actions in the Russian River watershed will have a range of effects on listed species and their habitats. This section provides:

- An overview of the level of SCWA's restoration and conservation actions within a given year and a description of how priorities are set.

- An overview of the Russian River watershed to put specific restoration actions into context.

- A qualitative assessment, based on evaluation criteria, of the biological benefit of proposed projects for affected life-history stages of listed salmonids.

- An assessment of effects due to construction and maintenance practices of the projects.

Some actions have been implemented since the MOU was signed (December 31, 1997), and represent an improvement to baseline conditions. They do not require a take authorization because they are not likely to result in direct injury to listed fish species. Actions that require take authorization are generally projects that require instream work while listed fish species may be present.

5.5.1 Program Overview

5.5.1.1 Funding and Priorities

SCWA commits substantial funds, staff, and equipment to restoration projects. The value of this commitment is maximized by prioritizing projects on a basinwide level, through cooperation with many other stakeholders, and by seizing opportunities for public education and outreach. Moreover, SCWA's success with grant writing has been, and would continue to be, used to supplement this effort.

SCWA has increased its budget and level of efforts for restoration and conservation actions within the last several years, and hopes to maintain the current budget in future years. Of the $800,000 spent on the Natural Resources program in 2000, about 30 to 40 percent was spent on monitoring at the Mirabel and Wohler diversion facilities (which has yielded valuable information about how listed species use the watershed), about 50 percent was spent on Fisheries Enhancement Program (FEP) projects, and about 10 percent on meetings. Additionally, in-kind contributions of SCWA staff and equipment have been committed to stream restoration projects. For example, $31,000 was committed for a large project on Copeland Creek and $7,000 for a project on Austin Creek.

In 1999, SCWA began to apply for grant money to supplement the restoration budget. For example, SCWA secured $400,000 of Proposition 13 funds to fund a program implemented by Circuit Rider Productions, Inc. for *Arundo donax* (Giant Reed) eradication in the Russian River watershed. The grant application was successful because a comprehensive approach to *Arundo* eradication was designed, rather than relying on less-effective spot treatments. This program includes mapping the entire watershed, developing a disposal and compost facility, and conducting eradication from the most upstream location to downstream areas. The mapping stage has been completed, and *Arundo* removal has begun. In some cases, SCWA has used grant money to jump-start projects by local organizations that match grants. In 2000, SCWA secured $471,000 in grants. If a landowner wanted to implement a joint project, SCWA would pursue a grant for that project. Given past successes, SCWA expects to secure additional grant funding in the future.

To maximize the effectiveness of the dollars invested, SCWA develops project priorities on a basinwide level. Stream habitat inventories coordinated by CDFG have identified restoration opportunities, and SCWA and CDFG have had a successful track record in working on multiple projects and efforts throughout the watershed. SCWA would work to implement the priorities and recommendations outlined by CDFG in its *Draft Russian River Basin Fisheries Restoration Plan* (CDFG 2002). The contribution of funding and implementation efforts from other stakeholders in the watershed—private landowners, agencies such as CDFG, NOAA Fisheries, the Sotoyome Resource Conservation District, and NCRWQCB, to name a few—have been instrumental to the success of restoration programs.

SCWA bases its decision to proceed on a project on one or more of the following considerations.

- Project has a known benefit. Projects that meet significant known needs and result in maximum benefit are given priority. A project may have been identified as a priority during a habitat survey and in consultation with CDFG. Relevant information is reviewed, including formal or anecdotal information from SCWA or CDFG staff or others, including whether a limiting factor is affected, and potential effects to the population of a listed species (with a priority focus on coho salmon). For example, some streams might have adequate spawning habitat, but need large woody debris to provide adequate rearing habitat. If a project has a small footprint but affects a large area (for example, 700 feet of work that provides fish passage past Mumford Dam affects 45 miles of stream), more value from the project can be realized. If a project has educational value as a demonstration project, it is considered more valuable.

- Opportunity-based project (willing landowner). Occasionally, a project is requested by a local landowner and approved by CDFG. Because so much of the watershed is in private ownership, landowner cooperation is important. Publicity about SCWA programs and demonstration projects that have already been implemented may increase the number of such opportunities in the future.

- Third-party cooperation. As information about SCWA programs spreads, individuals or organizations seek opportunities to develop cooperative projects.

- Another organization is better equipped. If SCWA sees a restoration opportunity that may be handled more effectively by another organization, it would contact that organization. For example, SCWA is well equipped for dam removal projects, but there may be a large fencing project that may be more appropriately handled by the California Conservation Corps (CCC) office in Ukiah.

SCWA is also providing staff and substantial support for federal and state salmonid recovery planning efforts. As of the end of 2003, SCWA has allocated $4.6 million for recovery planning.

5.5.1.2 Evaluation Criteria Scoring

Conservation and restoration actions discussed in Section 5.5 were evaluated quantitatively by assessing their biological benefits. Typically, larger projects provide more biological benefits than smaller projects. The biological benefit score was based on the project size (length of stream affected), the time frame for expected benefits, habitat elements affected and their relative importance to listed fish species, stream inventory and/or population data, the cost vs. benefits of the project, and the educational value of the project.

Some projects have effects beyond the immediate project area. For example, a series of small instream structures can beneficially change the habitat unit ratios of an entire reach (pool/run/riffle ratio). The habitat value was qualitatively assessed by considering the duration and time frame to development, effects to canopy cover, instream cover, sediment, and bank erosion. The importance of the project for improving a limiting factor was considered. Ranking was based on a range of 1 to 5 with a score of 5 given to projects with the most substantial biological benefits.

5.5.2 Salmonid Habitat in the Russian River Basin Relative to SCWA Restoration and Conservation Actions

An analysis of the effects of restoration and conservation actions on coho salmon, steelhead, and Chinook salmon requires an understanding of the importance of various geographic areas to the species' various life-history stages. Activities within a particular geographic area can then be assessed for their overall effect on populations of listed species.

SCWA has cooperated with CDFG to conduct stream habitat surveys. Surveys for all of the coho salmon streams and most of the watershed have been completed. The CDFG *Draft Russian River Basin Fisheries Restoration Plan* (CDFG 2002) lists priorities for restoration based on stream inventory data. Streams that can support coho salmon are given first priority.

Much of the watershed area is privately owned, and agricultural industries (such as vineyards) predominate. Restoration actions can be limited by a lack of willing landowners, so public outreach and demonstration projects are an important component of a restoration program.

Santa Rosa and the Cotati-Rohnert Park areas are the most urbanized portions of the watershed. These areas contain most of the constructed flood control channels. Natural streams and constructed channels in the Rohnert Park area are generally low-gradient and run through a valley plain to the foothills. Poor summer water quality and low summer flows limit rearing habitat. However, the Laguna de Santa Rosa has important wetland and flood control functions for this part of the watershed.

Santa Rosa Creek drains to the Laguna de Santa Rosa, which in turn drains to Mark West Creek. This part of the Mark West Creek watershed, including the Santa Rosa Creek watershed, contains good coho salmon and steelhead rearing and spawning habitat. Much attention has been given in recent years to restoration opportunities in this area.

The western side of the Russian River valley is cooler, and primary coho salmon spawning and rearing habitat occurs in tributaries in this region. Good quality coho salmon habitat also occurs in the Upper Russian River watershed and in parts of the Mark West and Maacama Creek watersheds.

5.5.3 Instream Habitat Improvements

By providing improved and/or additional rearing habitat, instream habitat improvements are important to the survival of coho salmon and steelhead in the Russian River watershed. When riparian cover is planted along streambanks, water temperature is reduced, additional cover is provided, streambanks are stabilized, erosion is reduced, and additional plant material becomes available to provide food and cover for insects upon which juvenile fish feed. Fish passage is also improved.

Instream habitat structures consisting of large woody debris, such as rootwads, have been installed to give fish protective cover from predators and to create pools. Bank stabilization and riparian planting have been implemented. Trees have been planted where riparian cover was lacking. Other types of structures such as boulder or log weirs, or some other combination of structures (as outlined in CDFG's *California Salmonid Stream Habitat Restoration Manual* [Flosi et al. 1998]) may be implemented. Channels may be reconstructed. For example, a section of Big Austin Creek was reconstructed to convert a braided, intermittent channel to a single thread, perennial stream, with a reconstructed spawning area. Other activities could include placement of spawning gravels, removal of obstructions, culvert improvements, or slide removal.

An individual project may be small in scale, but may make beneficial changes to a larger habitat unit, or to the proportion of habitat unit types in a reach (pool/run/riffle ratio). For example, Mill Creek has 14 sets of instream habitat structures. While each structure is short, collectively they change a long section of stream from primarily riffle habitat to a better combination of pool/riffle habitat.

SCWA has funded or implemented instream habitat improvements in Green Valley, Mill, Felta, Dutch Bill, Palmer, and Dry creeks. These projects greatly improve the habitat value of significant stretches of these streams for rearing salmonids. Table 5-59 summarizes information about these projects and shows a biological benefit score.

CDFG has recommended that these creeks be managed as anadromous, natural production streams. Moreover, SWCA has targeted these creeks for their importance to coho salmon and steelhead recovery. Where coho salmon or steelhead are known to be present in a particular stream, it is noted. However, improvements to habitat are likely to increase fish abundance in streams, and it may be possible for coho salmon to begin to use a stream in which they have not recently been documented, especially if there is a change in the pool/riffle/run ratio.

Table 5-59 Instream Habitat Improvement Projects

Creek	Size of Projects	Type of Project	Species* Affected	Biological Benefit	Project Completion Year
Green Valley	~ 1 mile	4 instream habitat structures	Co, St	5	2000
Mill	~ 2 miles	14 sets of instream habitat structures	St	5	1998
Felta	~ 2 miles	14 sets of instream habitat structures	Co, St	5	1998
Dutch Bill	6 pools	7 habitat structures	Co, St	5	2000
Projects that Require Take					
Dry	14 miles	Instream habitat structures	Co, St, Ch	5	
Palmer		Instream habitat structures	St	5	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

In spring 1995, CDFG surveys in Mill Creek documented many Age 0+ steelhead, indicating successful spawning, but few yearling fish, indicating poor holding conditions. The instream habitat project in Mill Creek will provide additional rearing habitat. The Green Valley, Felta, and Dutch Bill creek projects are particularly important because coho salmon have been documented in recent years. Dutch Bill Creek is a major tributary to the Lower Russian River and is therefore easily accessible to spawning salmonids. Palmer Creek is important because it contains good quality salmonid habitat.

5.5.3.1 Proposed Dry Creek Restoration

SCWA is planning restoration work for Dry Creek that would include constructing habitat improvement structures at suitable locations using boulders and redwood or fir trees to increase habitat complexity and available cover, and to provide areas that would hold coho spawning gravels. Coho salmon spawning gravels are smaller than those used by steelhead or Chinook salmon (Kondolf and Wolman 1993) and are therefore at a greater risk of being scoured during high flows.

Salmonids are most likely to construct redds in areas where periodic scour and fill of streambed gravels provide clean gravels that resist transport under all but the highest flows. Coho salmon redds are more vulnerable to redd-scouring stormflows, as they typically spawn early in the winter season, and in areas with smaller, more easily eroded gravel. Subsequent storms may be numerous, and peak flow events often occur after coho salmon have completed redd construction and egg laying.

Structures such as logs, large woody debris, or boulder clusters placed within the Dry Creek stream channel would create combinations of shear zones and pockets of slower moving water velocities surrounding the structures, and would serve to trap sediments during high-flow events. Deposits of clean, well-sorted gravels are likely to form near these structures, creating high-quality spawning sites. Protected gravels are also less likely to scour than gravels at some distance from the structures.

Dry Creek provides little available habitat for coho salmon (ENTRIX, Inc. 2003b) due to poor channel structure (i.e., general lack of pools or edge habitat with complex cover), and the general lack of woody debris. These features constrain production of both fry and juvenile coho salmon. Substantially increasing the amount and quality of habitat for coho salmon juveniles by adding structures would allow this stream to support larger numbers of fry and juveniles, and most importantly would lead to higher production of smolts. Placement of large woody debris within the channel would also improve rearing habitat for anadromous salmon and steelhead. This would provide refuge from high water velocities, supply cover for escaping avian predators, and encourage deposition of loose gravels and cobbles favored by invertebrate prey.

Dry Creek's habitat for young steelhead and Chinook salmon is affected in part by low habitat complexity. Habitat structures placed adjacent to high-velocity areas would benefit steelhead juveniles by providing velocity refugia adjacent to feeding lanes with abundant prey. All young salmonids would benefit from increased protection from high velocities associated with flows greater than 130 cfs (ENTRIX, Inc. 2003b).

Implementation of this project on Dry Creek would rate an effect score of 5. This project would greatly improve overall physical and, particularly, spawning habitat (coho salmon) in this stream.

Instream habitat improvement projects are likely to result in short-term increases in turbidity during construction if the work is done in a wetted stream, and during the first high-flow event of the following rainy season. Work in a wetted stream also has the potential to injure fish that may be in the area during construction. These potential effects are assessed in Section 5.5.8. Construction of instream habitat improvement projects may require take authorization.

5.5.4 Riparian Restoration

Riparian restoration projects include projects that exclude livestock from riparian zones, replant degraded areas with native vegetation, provide temporary water supplies to increase survival of newly planted trees, place bioengineered erosion structures such as willow mattresses and baffles, and/or plant native riparian trees in upslope areas.

Several general effects can be realized from riparian restoration. While reestablishing native riparian vegetation, this action, in turn, replenishes the natural functions of the riverine ecosystem. When riparian cover planted along streambanks has matured, water temperature is reduced, additional cover is provided, streambanks are stabilized, erosion is reduced, and additional plant material becomes available to provide food and cover for insects upon which juvenile fish feed. This is particularly beneficial for juvenile coho salmon, steelhead, and Chinook salmon rearing, but there may also be water-quality benefits for adult spawners. Furthermore, riparian cover can moderate temperatures for egg incubation. Passage conditions for juvenile fish may also be improved.

5.5.4.1 Fine Sediment Reduction

Riparian vegetation stabilizes or intercepts fine sediments that can smother eggs in the project area or in areas downstream. Sediment input into the stream reduces the amount of habitat for invertebrates and instream cover available to rearing juvenile fish by filling interstitial spaces under and between rocks. Projects that reduce sediment input to the stream often affect long portions of the channel downstream. Even projects of small size can have beneficial water-quality effects that extend downstream.

5.5.4.2 Livestock Exclusion

By fencing livestock from the riparian zone adjacent to the stream and replanting degraded areas with native vegetation, streambanks have become stabilized, riparian vegetation has been reestablished, and animal waste entering the stream has decreased. Benefits are realized within the project area and in downstream reaches.

5.5.4.3 Overall Benefits

Riparian restoration activities have the potential to affect all life-history stages of salmonids. As riparian vegetation takes some time to mature, the benefits of riparian restoration may take several years to be fully realized. Because riparian restoration activities often involve regrading streambanks, there may be some immediate reduction in sediment input to the stream and bank degradation.

Table 5-60 summarizes information about a number of riparian restoration projects on selected streams and shows a biological benefit score for each. Where coho salmon or steelhead are known to be present in a particular stream, it is noted. Improvements to habitat will likely increase future use by listed species. These creek projects are discussed in more detail following.

Table 5-60 Riparian Restoration Projects

Creek	Size of Project(s)	Type of Project	Species* Affected	Biological Benefit Score	Project Completion Year
Copeland	6,000 ft.	Fencing, grading, riparian planting;	St	4	1999, 2000, 2003
		Propagation of native plants and control of invasive non-native plants.	St	4	Funded since 2001

Table 5-60 Riparian Restoration Projects (Continued)

Creek	Size of Project(s)	Type of Project	Species* Affected	Biological Benefit Score	Project Completion Year
Green Valley	30 ft.	Erosion control and riparian planting	Co, St	Co - 5 St - 3	
Howell	4,000 ft.	Fencing	St	4	2000
Lytton	15 acres riparian habitat	Riparian planting with environmental education	St	5	2001
Turtle	500 ft.	Willow walls & mattresses	Co, St	3	1999
Turtle	> 1 mile	Irrigation	Co, St	5	1999
Felta	3 projects	Willow walls	St	3 (x3)	1999
Russell Irrigation Site on Turtle Creek	> 1 mile	Fencing	Co, St	4	1999
Unnamed tributary to Mark West (Huff property)		Willow wall	Co, St	3	1998

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

5.5.4.4 Copeland Creek

The project is on a valley floor reach of the stream in the Rohnert Park area. The watersheds within this area contribute substantial sediment loads to downstream areas. This portion of Copeland Creek goes dry in early summer, as does a downstream reach along Sonoma State University.

Approximately 6,000 feet of Copeland Creek streambank was restored when cattle and horses were excluded, eroded streambanks were recontoured, and native riparian species were planted. The project was implemented over 4 years. Sediment input to the stream was reduced when project components were completed, but it may take a few years for effects to be substantial in the stream and in downstream areas. Once the riparian vegetation has matured, additional and improved rearing habitat will be available.

Although the project will no doubt have ecological value for other biological resources, there is probably limited value for steelhead rearing in the immediate area. However, this is a project of significant size, and a reduced sediment load to the stream will benefit downstream portions of the watershed. The creek empties to the Laguna de Santa Rosa, which has important wetland and flood control functions. Portions of the Laguna de Santa Rosa, particularly areas where tributaries flow into it, may provide important salmonid habitat. The USACE is conducting a feasibility study to investigate the extent and causes of sedimentation in the Laguna de Santa Rosa. The Copeland Creek project will likely help reduce the sediment load to the Laguna de Santa Rosa. Such a large increase in the riparian zone is also likely to reduce water temperatures. Therefore, the biological benefit score is 4.

Since 2001, SCWA has funded Sonoma State University to offer a course in native plant propagation. Utilizing expertise and facilities on the campus, the course supplies the Copeland Creek watershed and other watersheds in the area with native plant materials, plant storage, and propagation services. In addition to direct benefits to salmonid-bearing streams from these restoration activities, this program educates students in the practical aspects of plant propagation and related restoration techniques.

SCWA has also funded efforts at Sonoma State University to study and control two invasive tree species that were threatening the native plant community on Copeland Creek: Tree of heaven (*Ailanthus altissima*) and sweet cherry (*Prunus avium*). These projects eliminated the dominant exotic canopy species from a large section of Copeland Creek and replaced them with native vegetation. These species can quickly become the dominant plant species and exclude native species. *P. avium* and *A. altissima* are small, relatively short-lived tree species that produce lower quality riparian and instream cover than the native trees they displace (e.g., oaks, maples, ash). In addition to restoring a high-quality riparian corridor, these projects increase our understanding of the dynamics of the spread of invasive species and the threat they pose to local streams. Although the project directly affects a localized area, the information gained from studies like these can be applied elsewhere in the watershed. Therefore, the biological benefit score is 4.

5.5.4.5 Green Valley Creek

Green Valley Creek is one of the few tributaries in the watershed that has supported a self-sustaining population of naturally-spawning coho salmon. Restoration actions on this creek may be particularly useful for conserving a native strain of coho salmon. Numerous small-scale projects have been implemented. Although the immediate project area of each one is generally small in size, the biological benefit for coho salmon may be high.

5.5.4.6 Lytton Creek

Restoration of 15 acres of native riparian habitat improved the riparian corridor of this salmonid-bearing stream. Because this project involved local high school students and members of the local community, it had a substantial educational value. It demonstrates that healthy ecosystems and farming can coexist. Therefore, the biological benefit score is 5.

5.5.4.7 Howell Creek

A 1998 CDFG stream inventory indicated that both riparian vegetation and stream channel conditions were degraded by unrestricted cattle grazing in an approximately 4,000-foot-long reach of Howell Creek, a tributary in Mendocino County. Marginal habitat for steelhead existed there. Exclusion of cattle and planting of native riparian species improved the streambanks and bed of this reach. Development of off-stream water sources helped to eliminate the need for cattle access. Reduction of fine sediment input, reestablishment of the riparian corridor, and reduction of streambed disturbance increase the habitat value of this and downstream reaches for rearing steelhead. Because this is a relatively large project with beneficial effects that extend downstream, the biological benefit score is 4.

5.5.4.8 Turtle Creek

The landowner for the Russell Irrigation site on Turtle Creek participated in a voluntary fencing project to exclude cattle from the stream in 1997. Because the creek was the main source of drinking water for Russell's livestock, an alternative water source was subsequently constructed. Water quality has been improved and riparian vegetation has a chance to mature. Fish habitat can be dramatically improved by this kind of conservation action. Over a mile of stream was fenced, and reduced sediment input will affect downstream reaches as well; therefore, the biological benefit score is 5.

5.5.5 Instream and Riparian Habitat Restoration

Instream structures promote pool and riffle habitats and provide bank stability. Large projects in Austin, Brush, Big Austin, Palmer, and Santa Rosa creeks include both instream and riparian habitat improvements. Green Valley and McNab creeks also have projects that includes erosion control, revegetation, and instream habitat structures. Because Green Valley Creek is one of the few creeks in the watershed that appears to still have a naturally-spawning coho salmon population, restoration projects are especially valuable. Biological benefit scores for these actions are summarized in Table 5-61.

Table 5-61 Instream and Riparian Restoration Projects

Creek	Size of Project	Type of Project	Species Affected*	Biological Benefit Score	Project Completion Year
Austin	2,500 ft.	5 boulder wing deflectors, 7 log/root wad structures, 3 willow baffles, native plants	St	5	
Brush	1,200 ft.	Streambed and bank regrading, instream structures, revegetation	St	5	1999
Big Austin	1,300 ft.	Reconstructed channel	Co, St	5	1998, 2000
Big Austin	0.5 mile	13 erosion control/riparian structures, willow baffles, willow wall, slide repair	Co, St	5	1998, 2000
Green Valley		Erosion control, revegetation, 2 instream habitat structures	Co, St	Co - 5 St - 4	2001
McNab		5 streambank stabilization sites and 9 instream structure sites	St	5	2001

Table 5-61 Instream and Riparian Restoration Projects (Continued)

Creek	Size of Project	Type of Project	Species Affected*	Biological Benefit Score	Project Completion Year
Palmer	3,000 ft.	7 instream habitat structures, 1,000 alder trees	Co, St	5	1998
Santa Rosa Creek	12.8 miles	Restore channelized creek to more natural form and function	St	5	2002

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

5.5.5.1 Brush Creek

Brush Creek channel was previously modified to handle a 100-year-flood event to protect local property. Spawning habitat has been available, but high summer temperatures have limited rearing habitat. Work was needed to restore salmonid habitat and to lower stream temperatures. Brush Creek restoration between the confluence with Santa Rosa Creek and Highway 12 was completed in 1999. Grading streambed and banks along 1,200 lf of the stream and implementation of instream structures have enhanced aquatic and riparian habitat throughout the project area. Improving pool and riffle habitats as well as bank stability has provided spawning and rearing habitat for steelhead. Native vegetation was also planted along the regraded banks. As this vegetation matures, it will provide cover, lower stream temperatures, contribute to the food chain, and reduce runoff and bank erosion, which will, in turn, improve conditions in Santa Rosa Creek. Given the amount of habitat that was improved in an area important to steelhead rearing, the biological benefit score is 5. The Brush Creek project also occurs in a heavily populated area of the watershed and therefore is useful for public education.

5.5.5.2 Big Austin Creek

Fish habitat was improved when 1,300 feet of braided, intermittent channel was reconstructed to single-thread perennial stream. The project included bank stabilization, placement of instream cover, and construction of willow baffles. Riparian vegetation was also planted along sections of the stream. As riparian vegetation matures, it will increase cover and reduce water temperature. Site monitoring in 2002 to 2003 showed that the site is stable. This project provides substantially improved coho salmon and steelhead spawning and rearing habitat.

5.5.5.3 Palmer Creek

Palmer Creek is a tributary to Mill Creek in the Dry Creek watershed. This project was implemented in summer and fall 1998. Instream structures, including seven cover/scour structures (logs and boulders), enhance 3,000 feet of coho and steelhead habitat. The 1,000 native alder trees that were planted will improve the riparian corridor. The size of the project, as well as its location in the watershed, make it important for coho salmon and steelhead spawning and rearing habitat.

5.5.5.4 Santa Rosa Creek

The City of Santa Rosa is undertaking a project to restore Santa Rosa Creek by returning substantial reaches of degraded, channelized creek to a more natural geomorphic and ecological form and function and improving water quality, while maintaining existing levels of flood protection. The USACE, SCWA, and Sonoma County are assisting the City of Santa Rosa. The restoration is also intended to benefit steelhead and other aquatic life. This is a very large project (12.8 miles) that is likely to result in much-improved water quality and restored habitat for listed fish species. Santa Rosa Creek (including some of the downtown reaches) has been identified as having value as spawning and rearing habitat (CDFG 2001b).

5.5.5.5 McNab Creek

McNab Creek is a potential salmonid-bearing stream in the Ukiah area (CDFG 1998b). SCWA funded the E Center's Mendocino Fisheries Program project that stabilized stream banks at five sites with bioengineering techniques and installed instream structures at nine sites. The instream structures created pools and improved rearing habitat. This project improved salmonid-rearing habitat in the vicinity of each of these sites, as well as reduced sediment input to downstream reaches. Therefore, the project benefit score is 5.

5.5.6 Rural Road Erosion Control

Projects that control rural road erosion reduce sediment runoff into valuable spawning and rearing habitat, and often help to reestablish riparian vegetation. Fine sediment can "smother" eggs by decreasing the amount of intergravel DO available to them. The habitat of aquatic insects that juvenile fish feed on can be buried. Primary productivity is reduced in turbid water. As salmonids are "sight feeders," their ability to feed in turbid water can be reduced. Increased sedimentation can bury the interstitial spaces in the substrate used by invertebrates and instream structure available for juvenile fish to use as cover. Some erosion-control activities, such as regrading banks or soil treatments, have immediate reductions in soil loss, but it may take several years before improvements are noted in the stream. Moreover, these activities often require the growth and establishment of riparian vegetation, so the time frame to full development may be 2 to 4 years. However, once they are established, these kinds of conservation actions can have dramatic and long-term effects. Furthermore, immediate and long-term project effects can occur in long distances downstream of the project site.

Two road erosion control projects are detailed below and given evaluation scores in Table 5-62. One is a project to decrease the sediment runoff from a road adjacent to Palmer Creek. The other reduces sediment runoff to Santa Rosa Creek in Hood Mountain Regional Park.

Table 5-62 Road Erosion Control Projects

Creek	Size of Project	Type of Project	Species Affected*	Biological Benefit Score	Project Completion Year
Palmer	1 mile	Road erosion control, instream structures	Co, St	5	2001 (additional work in 2000, 2001)
Santa Rosa (Hood Mtn.)	~100 yards	Road and landslide erosion control	Co, St	5	2000

*Co = coho salmon, St = steelhead

5.5.6.1 Palmer Creek Road Erosion Control

This project reduced sediment input from one mile of steep rural roadway within the Palmer Creek watershed. Reducing sediment input into the stream has enhanced the value of instream habitat structures funded by SCWA within this stretch of Palmer Creek.

A long portion of Palmer Creek is affected, but there has not been an acute sediment input problem to the stream. While sediment input to the stream was reduced when the project was completed, it may be several years before significant improvement of habitat quality in the stream may become apparent. This project improves rearing habitat for juvenile coho salmon and steelhead by decreasing siltation of cover, reducing turbidity, and improving habitat for aquatic insects. Furthermore, habitat for egg incubation for all three species that may exist at this site or downstream of it will be improved. The biological benefit score is 5.

5.5.6.2 Hood Mountain Regional Park

An eroding road adjacent to Santa Rosa Creek and a landslide on Hood Mountain Trail deliver fine sediment to the creek. The slide was stabilized, the road modified, and the slope gullies filled. This project significantly reduced erosion along about 100 yards of streambank, and reduced sediment input to downstream areas. Although sediment input to the stream was reduced, it may be several years before significant changes are seen in the streambed itself. Because this landslide has been a significant source of fine sediment input to the stream, the biological benefit score is 5. As the section of Santa Rosa Creek in the park contains valuable spawning and rearing habitat for steelhead and coho salmon, the project is particularly important.

5.5.7 Fish Passage

The primary benefit of fish passage is that additional spawning and rearing habitat becomes available to anadromous salmonids. The biological benefit from a fish passage project is proportional to the quality and amount of upstream habitat made available. Scores for specific projects are given in Table 5-63. All of the listed projects are given a score of 5 because a large quantity of habitat is made accessible. The Santa Rosa and Mumford Dam projects are especially beneficial because they provide access to high-quality habitat, provide it for coho salmon as well as steelhead, and in the case of

Mumford Dam, for Chinook salmon. These projects restore habitat connectivity, which benefits the ecological community that includes salmonids.

In general, fishways could increase predation on listed species if they concentrate juvenile salmonids. Because these fish passage projects do not concentrate juvenile salmonids, they do not increase the risk for predation on juvenile salmonids and do not increase the risk of poaching.

Table 5-63 Fish Passage Projects

Creek	Upstream Habitat Affected	Type of Project	Species Affected*	Biological Benefit Score	Year Completed
Santa Rosa (Hood Mtn)	10 miles	Rock weirs	Co, St	5	1999
Mumford Dam	45 miles	Rock weirs ~ 600 feet of channel	Co, St, Ch	5	2002
Crocker Dam	4.5 miles	Series of weirs. Regrade, stabilize and replant streambanks	St	5	2002

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

5.5.7.1 Mumford Dam Modification

Mumford Dam is an 8-foot-high dam, approximately 60 feet wide, located on the Russian River near the town of Redwood Valley. Since its construction in the early 1900s, the streambed downstream of the dam was down cut between 8 to 15 feet, which virtually eliminated fish passage and caused massive erosion and bank failure for approximately 600 feet downstream of the dam. Restoration involved recontouring the streambanks to a more stabile profile, revegetating with native plants, and constructing a series of weirs to facilitate fish passage. The dam owner also upgraded the diversion to comply with NOAA Fisheries screening criteria. A series of large rock weirs maintains the thalweg of the river, stabilizes the channel bed, and reduces bank erosion.

This project greatly improves upstream fish passage, making approximately 45 miles of high-quality spawning and rearing habitat available for steelhead and Chinook salmon, and possibly coho salmon, on the Russian River upstream of the Forks. As the native riparian vegetation becomes established, the streambank will be stabilized even further, and habitat within the 600-foot-long project area will be greatly improved. The reduction in bank erosion will also improve water quality in downstream reaches. Because a large amount of habitat is improved and made available for all three listed species, the biological benefit score is 5.

5.5.7.2 Crocker Creek Dam

When Crocker Creek Dam failed, the impact to Crocker Creek was significant. A large sediment load was released downstream from behind the dam, and the creek upstream of the dam experienced major erosion and collapsing banks. The remaining structure and associated debris pile formed a potential barrier to salmonid migration.

Components of the restoration project included demolishing and removing the remaining structure and debris, recontouring and revegetating the banks, and making biotechnical channel adjustments. The left and right banks upstream of the dam for a distance of 250 to 400 feet were regraded, reconstructed, and replanted with willows. An irrigation system was installed to water the vegetation until it is well-established. This project restored access for anadromous fish to 4.5 miles of creek, stabilized and revegetated streambanks in the vicinity of the dam, and reduced sediment input to downstream habitat. Because there are benefits for both upstream and downstream habitat, the biological benefit score is 5.

5.5.7.3 Santa Rosa Creek

Like the Mumford Dam modification, a series of large rock weirs at a rural road stream crossing in Santa Rosa Creek in the Hood Mountain region is designed to stabilize the channel bed and improve upstream fish passage. The project lowered the concrete road crossing and sloped the downstream side of the sill to reduce the jump height for fish. Rock baffles were installed on the downstream side of the sill to improve fish passage. The project was implemented by Dragonfly Stream Enhancement with a $7,685 FEP grant from SCWA. This project makes approximately 45 miles of quality spawning and rearing habitat available upstream. Therefore, the biological benefit score is 5.

5.5.8 Construction, Maintenance, and Operation Activities on Restoration Projects

Construction activities are likely to have minimal, if any, short-term effects on listed species or their habitat. These effects include short-term increases in turbidity and sediment input or a slight risk of injury to some individual fish. Therefore, instream and rural road erosion projects that are implemented in a wetted stream require a take authorization. As restoration projects act passively after construction is complete, no maintenance or operations effects are anticipated.

5.5.8.1 Riparian Restoration Projects

When riparian restoration projects are constructed on streambanks, instream work is not necessary. There is no potential for direct injury to fish during construction activities, and therefore, riparian restoration activities do not require take authorization. Installation of fences and establishment of native riparian vegetation could create limited-to-high levels of streambank disturbance, which, in turn, could increase sediment input to the stream. Bank erosion control measures such as detention basins, hay bales, and filter fabrics would be used as necessary. Upslope stability is improved once vegetation is established. The sediment containment score for riparian restoration projects is 3 (Table 5-64).

Table 5-64 Sediment Containment Scores for Riparian Restoration Projects

Category Score	Evaluation Criteria Category	Project Scores
5	No upslope disturbance, or an increase in upslope stability.	
4	Limited disturbance with effective erosion control measures.	
3	Moderate- to high-level of disturbance with effective erosion control measures.	Revegetation and erosion control projects
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel, or major changes in channel morphology.	

5.5.8.2 Instream and Rural Road Erosion Projects

Many instream habitat and road erosion projects are constructed when the stream is dry. For those streams, there is no sediment input to the stream and no potential for direct injury to fish during construction activities (Table 5-65). For the few channels that are wetted during construction, fish rescue would be performed. Turbidity and sediment input may increase during the first high-flow event of the rainy season. But these effects would be of short duration and may be indiscernible from turbidity normally associated with these events.

Table 5-65 Opportunity for Injury Scores for Restoration Projects

Category Score	Evaluation Criteria Category	Project Scores
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or above the tops of bars, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	Instream habitat improvement and rural road erosion projects
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

When work is done in a wet stream channel, it is under the terms and conditions of the USACE, NCRWQCB, and CDFG permits issued for the project. All measures possible would be used to reduce effects on the stream. If it is not possible to work in a dry channel, the site would be dewatered and a fish rescue implemented, if appropriate. For example, on Austin Creek, reconstruction of the toe of the bank was necessary, and BMPs were stipulated in the permit. A combination of detention basins, hay bales, and filter fabrics were used, and no sediment problems were identified. On Adobe Creek (not in the Russian River), a series of boulders were placed in an active stream to provide fish passage. Fish rescues were conducted to move as many fish as possible out of the project area. These examples demonstrate a clear commitment by SCWA to avoid any effects to the aquatic resources and listed species during implementation of restoration projects.

Sediment containment measures would be implemented in all projects (Table 5-66). While rural road erosion projects would result in short-term effects, with limited-to-high levels of disturbance to streambanks, effective erosion control measures are in place during construction when work is done near wetted channels. These projects are likely to increase upslope stability in the long-term.

Table 5-66 Sediment Containment Scores for Restoration Projects

Category Score	Evaluation Criteria Category	Project Scores
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	Projects in dry channels
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	All projects in wetted channels
2	Limited sediment control.	
1	No instream sediment control.	
	Component 2: Upslope Sediment Control	
5	No upslope disturbance, or an increase in upslope stability.	Instream structures
4	Limited disturbance with effective erosion control measures.	
3	Moderate to high level of disturbance with effective erosion control measures.	Rural road erosion control projects
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel or major changes in channel morphology.	

5.5.8.3 Fish Passage

Mumford Dam, Crocker Creek Dam, and Santa Rosa Creek fish passage construction projects were timed and implemented to minimize disturbance to rearing salmonids. While there was a risk to listed species and their habitat from construction activities, the use of standard BMPs made the risk low.

For any fish passage project, fish rescues would be performed, if necessary, reducing the opportunity for injury to fish (Table 5-67). Sediment traps or similar measures would be constructed to reduce instream sediment loads from construction activities. Bank erosion control measures would be used when planting native riparian vegetation, and up-slope stability would be improved once the vegetation is established (Table 5-68). Long-term benefits, including stabilized banks with a native riparian corridor and passage to additional spawning and rearing habitat, outweigh potential short-term risks to individual fish.

Construction activities are likely to have minimal, if any, short-term effects on listed species or their habitats. These effects include short-term increases in turbidity and sediment input or a slight risk of injury to some individual fish. Therefore, future construction of fish passage projects would require a take authorization.

Table 5-67 Opportunity for Injury Scores for Fish Passage Projects

Category Score	Evaluation Criteria Category	Project Scores
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or the tops of bars, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	
3	Appropriate BMPs are applied; e.g., project area survey, escape, or rescue provided, project area isolated from flow (if appropriate).	Mumford Dam, Santa Rosa Creek
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

Table 5-68 Sediment Containment Scores for Fish Passage Projects

Category Score	Evaluation Criteria Category	Project Scores
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	Mumford Dam, Santa Rosa Creek
2	Limited sediment control.	
1	No instream sediment control.	

Table 5-68 Sediment Containment Scores for Fish Passage Projects (Continued)

Category Score	Evaluation Criteria Category	Project Scores
	Component 2: Upslope Sediment Control	
5	No up-slope disturbance, or an increase in up-slope stability.	Mumford Dam, Santa Rosa Creek
4	Limited disturbance with effective erosion-control measures.	
3	Moderate- to high-level of disturbance with effective erosion control measures.	
2	Action likely to result in increased sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel or major changes in channel morphology.	

5.5.9 Watershed Management Projects

Watershed management projects provide key information that is needed to restore and protect habitat for listed fish species, and make it possible to apply this information on a watershed level to maximize the effects. Evaluation criteria for scientific research, demonstration projects, and information dissemination such as: in how wide a geographic area could the information be used, and whether the information is useful for the protection of listed species or their habitats (Table 5-69).

Table 5-69 Information Value Evaluation Criteria

Category Score	Evaluation Criteria Category
5	Basinwide applicability.
4	A region or "type" of habitat (i.e., small tributaries or lower mainstem).
3	Isolated project/stream information.
2	Information not useful to listed species or habitat.
1	Incorrect or misleading information.

Research efforts, information dissemination, and regional coordination of management efforts are important components of the restoration and conservation of listed species and their habitat. Table 5-70 summarizes information about actions that are part of the proposed project, the biological benefit scores, and where known, indicates the listed species the action is likely to affect. Steelhead are the most abundant species in many of these areas, but as coho salmon populations are recovered, the use of these streams by these species is likely to increase. All projects listed are likely to improve habitat for spawning, rearing, and migration of listed salmonids.

Table 5-70 Information Value Scores

Project	Range of Applicability	Information Value Score
Data Collection		
Stream habitat surveys	Basinwide – SCWA focus on Mark West and Santa Rosa Creek watersheds.	**5**
Temperature	Major tributary watersheds, trends over multiple years.	**5**
Water quality sampling	Austin Creek and Maacama Creek tributaries, Russian River mainstem, Mark West, Santa Rosa, Green Valley, Mill, Ackerman, Robinson, Dutch Bill, Hulbert, Fife, Franz, Porter, Redwood creeks.	**4**
Coho salmon and steelhead population monitoring	Basinwide	**5**
Genetic studies on coho salmon, steelhead, and Chinook salmon	Basinwide	**5**
Arundo mapping and research	Basinwide	**5**
Laguna de Santa Rosa sedimentation study	Regional application – Lower Russian River floodplain.	**4**
Russian River coho recovery stream monitoring	Six stocking streams that are part of the Coho Salmon Recovery Program's comprehensive long-term monitoring, and 3 control streams	**5**
Green Valley Creek Spawning Substrate Study	Green Valley Creek	**5**
Russian River Habitat Mapping	35 miles of mainstem channel between the Forks and Cloverdale	**5**
Demonstration Projects		
Pierce's Disease control study	Maacama Creek site, with potential application to other vineyards.	**5**
Fish Friendly Farming	Vineyards, the dominant agricultural industry in the watershed.	**5**
Palmer Road erosion control	Demonstration project helpful for other work in areas with road erosion problems.	**3**
Information Coordination and Dissemination		
KRIS/GIS database	Basinwide	**5**
Restoration Project Database	Basinwide	**5**
Information dissemination: Workshops, newsletters, library, training programs, school projects	Several projects with regional applications.	**4**
Federal and state recovery planning assistance	ESUwide	**5**
NCRWQCB Russian River Basin Plan review	Basinwide, and application to entire ESUs of listed fish species.	**5**
Watershed Management Plan	Regional applications	**4**
North Bay Watershed Assn (NBWA) participation	Regional applications	**4**
Clean-up days	Target specific streams	**3**

Basinwide applicability (score 5) addresses most or the entire watershed that is likely to be important to listed species. Isolated project/stream information is likely to be useful in a localized area, such as a particular stream or stream reach. Isolated project/stream information (score 3) is likely to be useful in a localized area, such as a particular stream or reach of a stream. Scores are assigned for the various projects based on the range of applicability and on a qualitative assessment of the biological benefit that may accrue.

5.5.9.1 NCRWQCB Russian River Basin Plan Review

SCWA has provided funding for the NCRWQCB to review the Russian River Basin Plan to determine whether the Basin Plan's water quality requirements are sufficient to protect fish in the Russian River. This review may lead to changes in regulatory standards that increase protection of listed fish species. Changes in these standards would not only affect management of the Russian River watershed, but of the entire portion of the ESU of each listed fish species in the North Coast region, in coordination with other California state regional water quality control boards through the North Bay Watershed Association (NBWA).

5.5.9.2 Population and Habitat Surveys

SCWA is participating in a comprehensive survey of listed salmonid populations and their habitats throughout the Russian River. This information is key to effective management and restoration. Studies have also been funded to determine the genetic population structure in the Russian River and other watersheds in the ESU so that locally adapted "wild" stocks can be identified and given additional protection.

Population monitoring may result in injury or mortality to some individual fish. However, the benefits of having data to help effectively manage the resource outweigh the potential to harm some individual fish. Take of listed fish species is addressed in the NOAA Fisheries fish sampling permitting process.

5.5.9.3 Temperature Monitoring

The NCRWQCB, with funding from SCWA, has organized a Temperature Summit to coordinate various organizations to conduct comprehensive water temperature monitoring in the watershed. Priority is given to salmonid-bearing streams or impaired streams that need improvement. Collectively there are about 300 sample locations in the basin. Some organizations participating in the Temperature Summit have access to privately owned land that other organizations might lack.

Temperature data are entered into the KRIS database and are used in several ways. For streams that have good water temperatures but no salmonids, limiting factors for sensitive life-history stages are sought. Water temperature problems that might affect coho salmon are identified. This includes areas where water temperatures increase. Where possible, areas that contain subsurface flow for thermal refugia are also identified. CDFG monitors individual tributaries for one season. SCWA monitors temperatures over several seasons to document long-term trends. Combined, these data are crucial to help identify priority restoration opportunities.

5.5.9.4 Pierce's Disease Control

SCWA funded a study on Maacama Creek to investigate methods of controlling Pierce's disease. The study investigated means to selectively remove non-native plants that serve as sharpshooter hosts, while maintaining a viable riparian community. This project was conducted by researchers at the Division of Insect Biology, University of California, Berkeley. The study demonstrated that selective removal of vegetation can control an insect vector of Pierce's disease. Furthermore, the reductions in populations of glassy-winged sharpshooters have been greater than those achieved by insecticide treatments of riparian areas. The insects that carry Pierce's disease generally favor non-native vegetation. Leaving native vegetation that the insects do not use will help maintain the benefits of a healthy riparian corridor. If riparian vegetation is indiscriminately removed to prevent the spread of this disease, habitat for listed species can be degraded.

The information from this study could be applied in other riparian corridors that pass through vineyards. Because the need for information on effective control is actively being sought by growers, this information could significantly decrease the amount of riparian vegetation that is currently being removed from habitat.

5.5.9.5 Habitat Studies

The Russian River Coho Salmon Recovery Program's comprehensive long-term monitoring program will install stage and stream temperature monitoring equipment in six streams to be stocked with coho salmon, as well three control streams. These data are critical to the monitoring evaluation efforts for the reintroduction of coho salmon to restored habitat. Because this is an important component of the effort to increase the abundance of coho salmon in high-priority streams, the biological benefit score is 5.

SCWA has funded a joint effort between O'Connor Environmental, Inc. and Circuit Riders Productions to perform a fluvial geomorphic analysis and characterize spawning substrate in Green Valley Creek. Because this information will help guide restoration efforts on one of the only streams in the watershed that has had a naturally-spawning coho population in recent years, the biological benefit score is 5.

The Russian River between the Forks and Cloverdale contains some of the best Chinook salmon and steelhead spawning and rearing habitat in the mainstem. SCWA has funded a study to map the locations, depths, areas, and temperatures of pools, map and measure salmonid spawning sites, and map the locations of erosion sites. Because this study focuses on a long (35 miles) and important reach for these two species, particularly for Chinook salmon, the biological benefit score is 5.

5.5.9.6 Fish Friendly Farming

The Fish Friendly Farming program, implemented by the Sotoyome Resource Conservation District with SCWA's assistance, gives landowners the knowledge and incentive to practice beneficial management practices that protect fish habitat. Participants learn such topics as evaluation of natural features, current practices, roads, soils, slopes and drainage, and riparian corridor restoration and management. Because this program targets the region's dominant agricultural industry, wide-scale adoption of this program could result in fish habitat improvements in a substantial portion of the watershed.

When implemented, BMPs outlined in the *Fish Friendly Farming Certification Program Farm Conservation Plan Workbook* increase the habitat value of streams for listed fish species by decreasing sedimentation of streams, increasing the quality of the riparian corridor, and improving instream habitat. A marketing component designed to increase the value of wine produced by these growers gives a financial incentive to certified growers and is likely to increase the level of success of this program. Additional financial assistance for restoration efforts would be sought.

5.5.9.7 Palmer Road Erosion Control

In addition to reducing sediment input from a mile of steep rural roadway, this project has value as a demonstration project for effective rural road erosion control. Application of these techniques to other rural roads in the watershed could substantially reduce erosion in this basin.

5.5.9.8 Federal and State Recovery Planning

SCWA is providing staff and substantial financial support for federal and state recovery planning efforts. As of the end of 2003, SCWA has allocated $4.6 million for recovery planning. These efforts are vital to coho salmon recovery. Coordination of recovery efforts throughout the basin and within the ESU would focus scarce resources where they are likely to do the most good. This is likely to improve metapopulation structure of existing populations and result in increased chances of long-term survival of the species.

5.5.9.9 Invasive Plant Species

Non-native plant species have the potential to seriously impair the natural functions of the Russian River ecosystem. Of particular concern is *Arundo donax.* Information about the influence of invasive weeds on native riparian vegetation and insects is needed to assess the effects on the aquatic ecosystem that supports coho salmon, steelhead, and Chinook salmon. By funding studies, developing effective control measures, and controlling *Arundo* while it is still manageable, SCWA is working to prevent the devastating level of infestation that occurs in streams in southern California.

The extent of *Arundo* infestation has been determined and mapped. Many areas in the Alexander Valley have been dominated by *Arundo* (Natural Resources Management Corporation 1999). These could serve as source populations from which downstream areas are colonized. Identification of areas where *Arundo* has taken hold is an important first step in the effort to control it.

Arundo removal and establishment of native riparian vegetation is an important conservation action that could have significant localized effects throughout the river basin. Therefore, the biological benefit score is 5 (Table 5-71). *Arundo* is generally removed with a combination of mechanical means and application of an herbicide approved for aquatic use. As eradication efforts target non-native vegetation, and the herbicide is applied by trained personnel, the benefits of *Arundo* eradication far outweigh minimal risk of short-term effects that may occur from herbicide use (Table 5-72). As *Arundo* is very difficult to eradicate, research that could identify effective methods for restoring *Arundo* patches to native vegetation would be invaluable.

Because *Arundo* is available in nurseries, educating the public about *Arundo* and coordinating volunteer efforts for its removal is an important component of an effort to eradicate this invasive weed and prevent its spread or reintroduction. SCWA distributes a native riparian plant handbook to assist individuals and groups, and this information will help control the spread of invasive species. SCWA is taking a watershed approach to the control of non-native weeds because a basinwide effort is needed to keep *Arundo* under control.

Table 5-71 Non-Native Vegetation Removal Biological Benefit Score (*Arundo donax*)

Category Score	Evaluation Criteria Category	Project Score*
5	Very high potential to benefit.	Co, St, Ch
4	High potential to benefit.	
3	Moderate potential to benefit.	
2	No benefit and uses scarce resources.	
1	Poorly planned or implemented, degrades habitat.	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

Table 5-72 Vegetation Control Score for *Arundo donax*

Category Score	Evaluation Criteria Category	Project Score*
5	No chemical release.	
4	Limited use of herbicide approved for aquatic use in riparian zones or over water.	
3	Moderate to heavy use of herbicide approved for aquatic use in riparian zones or over water.	Co, St, Ch
2	Use of herbicide not consistent with instructions.	
1	Use of herbicide not approved for aquatic use in riparian zones or over water.	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

5.5.10 Riverfront Park Reclamation

A property recently acquired by SCWA is to be restored as Riverfront Park. Three former gravel mining pits located on the property have filled with water and are now referred to as Lake McLaughlin, Lake Wilson, and Lake Benoist. These lakes have the potential to entrain salmonids when floodwaters recede after high-flow events. The property is located in the Lower Russian River and adult and juvenile salmonids of all three listed fish species may be affected.

Floodwater can flow through an opening in the riverbank upstream of the property at the Doyle Pit (elevation 63.5 feet NVGD and a 1.75-year return interval) and enter Lake McLaughlin, providing a conduit for fish passage to the lake. Floodwater can overtop the banks on the northwest side of the property (2-year return interval). Flow can back up through a rock riprap weir at the southern end of Lake Benoist and flow to Lake Wilson. When waters are high enough (60.5 feet NVGD), water can flow between Lake Wilson and Lake McLaughlin (1.25-year return interval). At high flood flows, the entire area can be under water (10-year flood event). When floodwaters recede, water drains back to the river through the weir at the southern end of the property (53 feet NVGD). Fish passage back to the river over this weir is only available as long as water flows over it. Fish passage from Lake McLaughlin is available when water flows between Lake Wilson and Lake McLaughlin.

During the summer, some of the lake water seeps back to the river. However, the lakes retain water all year and the deepest lake has a depth of over 50 feet.

Salmonids migrating or rearing in the vicinity can be entrained into these lakes. Once flood flows recede, no passage out of the area is available. The lakes are too large and deep to conduct effective fish rescue. Steelhead trapped in the lake are likely to revert from the anadromous to resident form of trout and may be subject to fishing pressure. Coho and Chinook salmon trapped in the lake are likely to be lost to the effective population. These risks associated with entrainment were present even before SCWA acquired the property.

The risk of entrapment is based upon opportunity for escape or rescue. Passage past the lakes is also evaluated for the opportunity for entrapment or injury based on the amount of streamflow diverted and the amount of time water is diverted during a species life-history stage. Finally, the risk of predation to salmonids in the river if predators from the lake are released is evaluated.

5.5.10.1 Risk of Entrapment

The lakes flood when river flows overtop the banks. Fish passage is not available after flood flows recede, and fish rescue is infeasible. Salmonids entrained in the lake are likely to be lost to the listed anadromous population. The opportunity for entrapment is based in part on how much water is diverted and how often the water is diverted. There are no estimates of the percentage of flow that is diverted during high flows, but it is assumed that it can be a significant volume. Flood flows can enter Lake McLaughlin on a return interval of 1.75 years, so only a small portion of the migration period is likely to be affected. Applying evaluation criteria for the amount of time water is diverted, the score is 4 (Table 5-73).

Migrating salmonids that are passing through during one of these flood events have a high risk of being entrained, but one of these events only occurs about once every 1 or 2 years. The park property is located in the Lower Russian River and juvenile salmonids of all three species that migrate from upstream areas during one of these events are at risk. Upstream adult migrants may also be entrained.

Table 5-73 Passage Scores for Juvenile Salmonids – Opportunity for Entrapment, or Injury at Riverfront Park Lakes –Time Water is Diverted

Category Score	Evaluation Categories	Current Operations Score*
5	Facility does not affect surface water flow during any time of migration period.	
4	Facility diverts surface flow during less than 10% of migration period.	Co, St, Ch
3	Facility operates between 10% and 15% of migration period.	
2	Facility operates between 15% and 25% of migration period.	
1	Facility operates during more than 25% of the migration period.	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

5.5.10.2 Predation

These lakes may create warmwater habitat for fish species that prey on salmonids. There already are self-sustaining populations of the warmwater fish communities in the Lower Russian River. If predators are released from the Riverfront Park lakes, warmwater fish populations could be supplemented in the Russian River. Fish passage from the lakes is only available during high-flow events, so predators have limited opportunities to enter the river. Furthermore, during the high-flow season, river conditions are not favorable to non-native warmwater fish species. High summer water temperatures are likely to limit the quality of summer rearing habitat for salmonids in the vicinity, but the lakes are located in the Lower Russian River, and downstream migrants from the watershed upstream would pass through the area. However, because there already is a warmwater fish community established in the vicinity, these lakes are not likely to introduce a new or substantial risk of predation to migrating or rearing salmonids.

5.5.11 Water Conservation and Recycled Water

SCWA plans to undertake water conservation measures that will reduce demands on SCWA’s water transmission system. This program is designed to reduce peak water demands, which typically occur during the dry season in mid-summer. Water reuse and conservation could reduce peak water demand from 3 to 5 percent. Water conservation is expected to help meet future, growing, water demands and may help to reduce the amount of water diverted from streams.

5.6 FISH FACILITY OPERATIONS

This section evaluates effects on the three salmonids for each of three proposed hatchery programs: an isolated steelhead harvest program; an integrated coho recovery program using captive broodstock; and a "no production" option for Chinook salmon. This discussion is organized into categories that encompass functional requirements of hatchery production. Following each hatchery operations category, a table is presented that ranks the risk posed by each of the three hatchery programs. Evaluated effects include water quality, water quantity, and genetic and ecological risks associated with hatchery production. There is also an assessment of benefits that should arise from implementation of the three proposed programs.

The Section 7 Consultation between NOAA Fisheries, USACE, and SCWA addresses a time-frame extending well beyond the 2007 expiration of the current coho salmon captive broodstock pilot program. In light of current low numbers of coho salmon in the Russian River basin and in anticipation of information to be collected from the pilot program, this analysis evaluates a captive broodstock program and a supplementation program utilizing capture of adults. The objectives of the proposed coho program are to 1) prevent extirpation of Russian River coho salmon, 2) preserve genetic, ecological, and behavioral attributes of Russian River coho salmon while minimizing potential impacts to other stocks and species, and 3) build a naturally-sustaining coho salmon population.

This section also evaluates the effects of the proposed isolated harvest program for steelhead and the proposed "no production" program for Chinook salmon. The justification for the steelhead program is to provide mitigation for loss of habitat resulting from construction of Warm Springs Dam and Coyote Valley Dam, incorporating measures as necessary to minimize negative effects on listed fish species. The justification for the "no production" program for Chinook salmon is to eliminate any potential negative effects to listed fish populations that may arise from non-essential hatchery activities.

Information presented in Appendix C, and FishPro, Inc. and ENTRIX, Inc. (2002) described the genetic and ecological risks of hatchery production with respect to the major theoretical and observed effects to wild salmonid populations. There was also discussion of the general hatchery practices and management decisions that have potential to affect each risk issue. Data are currently being collected that will provide a greater understanding of the status and genetic characteristics of naturally-spawning steelhead and Chinook salmon in the Russian River basin. Depending on the results of those data collection efforts, it may be more appropriate to conduct an integrated harvest program for steelhead, and/or an integrated recovery (supplementation) program for Chinook salmon. This section consequently evaluates those two programs as future alternative programs for steelhead and Chinook salmon.

5.6.1 EVALUATION OF EFFECTS OF PROPOSED FISH FACILITY PROGRAMS ON LISTED SPECIES

5.6.1.1 Water Quality

Effluent water quality discharge limits have been established by the NCRWQCB to meet beneficial uses of the receiving waters. For DCFH, this includes Dry Creek and the Russian River. At CVFF, the beneficial uses are established for the East Fork Russian River below the outfall and the mainstem Russian River. Beneficial uses for both sites are the same and include the following uses applicable to the target species of this evaluation: cold freshwater habitat; preservation of rare and endangered species; fish migration; and fish spawning (NCRWQCB 1997a, 1997b). The daily maximum effluent limits established in the permits are created to meet these beneficial uses and allow for either a minimal acceptable change or no change to the receiving waters.

Discharge standards for the Russian River fish production facilities are specified in the following NPDES permits issued by the NCRWQCB:

- Don Clausen Fish Hatchery: Order No. 97-61, NPDES Permit No. CA0024350 (NCRWQCB 1997a).
- Coyote Valley Fish Facility: Order No. 97-60, NPDES Permit No. CA0024791 (NCRWQCB 1997b).

The permits require that the facilities be equipped with waste treatment equipment to ensure compliance with specified water quality criteria (Table 5-74). The key piece of equipment at DCFH is an in-line earthen settling pond that provides solids removal treatment of the entire hatchery discharge, while CVFF is equipped with an off-line concrete settling basin that treats only the wastes generated during raceway cleaning. Compliance with discharge standards is monitored by sampling the facility effluent two times per month, with results submitted in a monthly report to the NCRWQCB. Sampling must occur during cleaning operations, because this is the aspect of fish production that is most likely to produce poor water quality conditions.

Table 5-74 Discharge Standards for DCFH and CVFF

Parameter	Effluent Limit (Daily Maximum)
Total Suspended Solids	15 mg/l
Total Settleable Solids	0.2 ml/l/hr
pH	within 0.5 of receiving waters
Salinity (chloride)	250 mg/l
Temperature	no measurable change to receiving water
Turbidity	no increase > 20% of background
Dissolved Oxygen	> 7.0 mg/l
Flow – DCFH	15.5 mgd
Flow – CVFF	7.11 mgd

The discharge permits include operational stipulations in addition to the monthly monitoring noted above. For example, direct discharge of wastes from pond cleaning and the bypass of wastes around the pollution control pond are prohibited. At DCFH, it is prohibited to discharge detectable levels of chemicals used for the treatment or control of disease, other than salt (sodium chloride).

Both DCFH and CVFF have been in continuous compliance with their NPDES permit requirements (Table 5-75) (R. Gunter, CDFG, pers. comm. 1999). During times of high turbidity in the influent water, the hatchery may actually discharge water less turbid than that received, thereby benefiting the receiving waters. The DO level in the receiving waters during times of low flows may drop below the 7-mg/l limit and therefore may benefit from the hatchery maintaining a > 7-mg/l effluent limit. Effluent from the hatchery will contribute to the total load of solids in the receiving waters. The settleable and suspended solid levels discharged are slightly higher than incoming water, but are within the limits of the NPDES permits (R. Gunter, CDFG, pers. comm. 1999).

Table 5-75 Water Quality Evaluation Criteria and Scoring for Salmonids

Category Score	Evaluation Criteria Categories	Score
5	Continuous compliance with NPDES standards.	Co, St, Ch
4	Compliance with 75-99% of standards.	
3	Compliance with 50-74% of standards.	
2	Compliance with 25-49% of standards.	
1	Compliance with 0-24% of standards.	

Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Proposed changes to the DCFH water supply system will increase the facility flow capacity to 50 cfs (32.3 mgd) (see Section 4.6.5.1). Increasing the flow rate through the settling pond may affect the solids removal efficiency of the treatment system, although the very large size of the settling pond and its past effectiveness suggest there will be negligible impact to the solids removal efficiency. At the same time, the proposed DCFH production program will reduce the total annual solids loading into the settling pond to approximately 74 percent of the solids loading which occurred under the baseline production goals. The combined effect of these two factors is expected to result in facility discharge solids loadings that are equal to or less than baseline loadings, and instantaneous solids concentrations that are significantly less than baseline conditions. Implementation of the DCFH water supply modifications project will require an amendment of the NPDES permit (since the existing permit limits the maximum flow to 15.5 mgd), and a rigorous engineering evaluation will be conducted as part of the NPDES amendment process to ensure that water discharge standards are satisfied under the modified conditions.

In the interim period before modification of the water supply system, the water quality of the DCFH effluent is not likely to significantly degrade water quality in Dry Creek or the Russian River, based on the past compliance with discharge standards and the reduced solids loading expected under the proposed production program. At CVFF, which will continue the same production program as occurred during the baseline, the past compliance with its NPDES discharge permit indicates the water quality of the CVFF effluent is not likely to significantly degrade water quality in the East Fork Russian River or the mainstem Russian River.

5.6.1.2 Water Quantity

The total hatchery water demand at DCFH for full-capacity fish production operations is 25 cfs. When broodstock collection and holding operations are occurring, the demand increases to approximately 35 cfs to provide attraction flows for adult fish migrating upstream and to provide flows to maintain the fish in holding ponds once they enter the hatchery. The emergency water supply is in fully charged condition. However, hatchery staff are required to contact USACE to open the valve for access to the emergency water supply, and delays are possible. As water demand increases for the coho captive broodstock program over the next several years, it is important that an increased and reliable source of water be available.

The new water supply line proposed for the DCFH will tap into the existing wet well and provide a single pipeline capable of delivering 50 cfs of gravity-flow reservoir water to the DCFH facilities. This new water-supply line will provide a reliable and sufficient water source. A feasibility study to evaluate the most appropriate design of the water supply line will be completed in 2004, and construction of the modifications may be complete by 2007. Interim water supply needs will be supplemented by installing pumps in Lake Sonoma, if necessary.

The configuration of the water supply intake location with respect to the facility effluent discharge location at DCFH results in a bypass reach of approximately 900 feet for which the hatchery flow rate is diverted from the instream flow of Dry Creek. At CVFF, a similar bypass reach exists for approximately 950 feet of the East Fork Russian River immediately below Coyote Valley Dam. These bypass reaches are acknowledged and accommodated through minimum streamflow provisions contained in D1610 (see Section 1.4.3).

5.6.1.3 Genetic and Ecological Effects

This section presents an analysis of the risks and benefits for each species associated with implementation of the proposed fish facility programs. The potential risks of hatchery production to listed species fall into two areas, genetic risks and ecological risks. Genetic risks may include loss of diversity within and between populations, outbreeding depression, and inbreeding depression. Ecological risks to listed species may include increased competition for food, habitat or mates; increased predation; disease transfer; altered migration behavior; long-term viability; artificial selection; disproportional survival; and harvest bycatch. These risks and the associated hatchery operations that may contribute to each risk are summarized in Table 5-76 and discussed below.

Table 5-76 Hatchery Production Risks to Wild Salmonids and the Associated Hatchery Operations that May Contribute to Each Risk

Hatchery Production Risks to Wild Salmonids	Hatchery Operations That May Contribute to Each Risk						
	Source of Broodstock	Number of Broodstock Collected	Broodstock Sampling and Mating	Rearing Techniques	Release Strategies	Duration in Hatchery Captivity	Harvest Management
Genetic Risks							
Loss of Within-Population Diversity	X	X	X	X		X	
Loss of Between-Population Diversity	X				X		
Outbreeding Depression	X		X				
Inbreeding Depression	X	X					
Ecological Risks							
Competition					X		
Predation					X		
Disease Transfer				X			
Outmigration Behavior					X		
Long-Term Viability				X			
Artificial Selection	X			X		X	
Disproportional Survival		X	X				
Harvest Bycatch							X

In the following section, these hatchery practices are described as they apply to the proposed coho salmon, steelhead, and Chinook salmon production programs for the Russian River fish facilities. Due to the diversity of hatchery operations, this discussion is organized into seven categories that encompass functional requirements:

- Sources of Broodstock
- Numbers of Broodstock
- Broodstock Sampling and Mating Protocols
- Rearing Techniques
- Release Strategies
- Duration in Hatchery Captivity
- Harvest Management

Sources of Broodstock

Coho Salmon

Some genetic data are available for coho salmon spawning aggregates within the Russian River and surrounding basins. The following summary is based on data analyzed by various management agencies, as presented at the Russian River Coho Recovery Work Group meetings and described in greater detail in Section 2.2.5 of this report. In general, existing genetic data support the current ESU designation for the Russian River and surrounding basins and the following preliminary conclusions:

- Samples from Green Valley, Mark West, and Maacama creeks cluster unambiguously. These samples are very different from Russian River hatchery samples and from Olema Creek (Hedgecock et al. 2003; Garza and Gilbert-Horvath 2003).
- Green Valley samples exhibited a high degree of relatedness, suggesting that there is a substantial risk of inbreeding if these fish are used as a source of broodstock.
- Both Lagunitas and Russian River samples show signs of inbreeding.

The existing Russian River Coho Recovery program implemented broodstock collection efforts in 2001 and 2002. More than 300 coho salmon juveniles were collected each year for captive rearing from several locations as noted in Table 5-77.

Table 5-77 Juvenile Coho Salmon Collected for Russian River Captive Broodstock

Year	Total	Olema	Russian River Sources
2001	304	120	Mostly Green Valley
2002	459	150	Green Valley, Mark West, Dutch Bill

Source: Russian River Coho Enhancement Monitoring and Evaluation Subcommittee (2/27/03)

The risk of eroding between-population diversity can be controlled by: 1) maximizing the contribution of locally-derived juveniles and adults in the broodstock, and 2) minimizing the probability of straying. Given that preliminary genetic data suggest the presence of stock structure within the Russian River, erosion of this stock structure could occur if managers propagate a composite stock of coho salmon, and outplant their progeny throughout the basin. However, the risk of inbreeding depression, which might result from an attempt to propagate multiple stocks of very small size, may outweigh the risks of homogenization, particularly if the observed stock structure is the result of bottlenecks, or extreme genetic drift, resulting from high mortality and small population size. The available data are insufficient to adequately assess whether homogenization presents a lower risk than propagation of many small stocks. However, given the difficulty encountered in collecting large numbers of juvenile coho salmon, the use of a composite stock may be unavoidable.

NOAA Fisheries is conducting a genetic analysis of the fish collected for the captive broodstock program to add to the understanding of the population structure of local coho salmon stocks and to facilitate program breeding decisions. These data will be used to evaluate the relative risks of inbreeding and outbreeding depression as the capture, mating, and release protocols are developed for the captive broodstock program.

The source of broodstock used in hatchery operations has the potential to affect the wild population, primarily through the mechanism of outbreeding depression. Depending on specific circumstances, the source of broodstock also has potential to contribute to loss of within-population or between-population diversity, inbreeding depression, or straying of the hatchery-reared component. However, by utilizing local stocks as the source of broodstock, the source of genetic material in the first-generation hatchery component is presumably identical to that of the wild population. Because the abundance of local stocks are insufficient to meet the broodstock demand, then the priorities noted by FishPro and ENTRIX, Inc. (2002) can provide the basis for selecting alternative sources while minimizing risk to the wild population. Table 5-78 gives the scores for the coho captive broodstock program for the early (score of 4) and later (score of 5) stages. Due to the inability to locate sufficient numbers of coho salmon within the Russian River basin, the first-year implementation of the current coho recovery program obtained approximately one-third of the broodstock from Olema Creek in the adjacent Lagunitas watershed. Subsequent years of collection will attempt to increase the proportion of broodstock collected from the Russian River basin.

Table 5-78 Source of Broodstock Evaluation Criteria and Scoring for Coho Salmon, Steelhead, and Chinook Salmon

Category Score	Evaluation Criteria Categories	Score
5	Local broodstock source (target stock), collected in the most unbiased manner possible.	Coho supplementation or captive brood (later stages). Chinook "no production."
4	Naturally-spawned broodstock source from the nearest watershed; or a combination of naturally-spawned and hatchery-reared broodstock from the local source.	Coho supplementation or captive brood (earliest stages).
3	Hatchery-reared broodstock source from the local or nearest watershed; or naturally-spawned broodstock source from within the same ESU.	Steelhead isolated harvest.
2	Hatchery-reared broodstock source from within the same ESU; or naturally-spawned broodstock source from a different ESU.	
1	Hatchery-reared broodstock source from a different ESU.	

Steelhead

The isolated harvest program would derive all broodstock from the supply of adult steelhead returning to the hatchery. DCFH steelhead were not listed as part of the Central California Coastal (CCC) Steelhead ESU because information concerning the hatchery stock is sparse, and therefore the stock's relationship to the entire ESU is uncertain.

Fortunately, some genetic data are available for steelhead spawning aggregates within the Russian River and surrounding basins. In general, existing genetic data support the current ESU designation for the Russian River and surrounding basins and the following preliminary conclusions:

- There is a large relative magnitude of diversity among steelhead populations in California, particularly south of the Klamath River.
- Samples from south of the Eel River form a genetically diverse cluster that joins the other West Coast steelhead populations, apart from the inland clusters.
- Although steelhead in California are more similar to other coastal populations than to inland steelhead from the Columbia River basin, there is a great deal of diversity in the coastal steelhead groups.
- Historic stock transfers may have introduced divergent lineages into hatchery stocks, as evidenced by the greater number of mtDNA types found in hatchery stocks of steelhead as compared to geographically proximate wild populations (Nielsen 1994).

The source of broodstock used in hatchery operations has the potential to affect the wild population primarily through the mechanism of outbreeding depression. Depending on specific circumstances, the source of broodstock also has potential to contribute to loss of within-population or between-population diversity, inbreeding depression, or straying of the hatchery-reared component. Historically, outplanting occurred using broodstock from out-of-basin sources, but since 1990, all steelhead releases are progeny of broodstock collected from within the basin. The source of genetic material in the hatchery component may be similar to that of the wild population. Currently, no broodstock are collected from the natural population; only hatchery-origin fish are used in the spawning protocol. A score of 3 is given for broodstock for the steelhead isolated harvest program (Table 5-78).

Chinook Salmon

Some genetic data are available for Chinook salmon spawning aggregates within the Russian River and surrounding basins. The following summary is based on data analyzed by various management agencies and by researchers at the Bodega Marine Lab. In general, existing genetic data support the current ESU designation for the Russian River and surrounding basins, and the following conclusions:

- Fall-run Chinook salmon in the California Coastal ESU are generally distinct from populations in adjacent ESUs, with the possible exception of fall-run Chinook from Blue Creek, in the lower Klamath River (Banks et al. 1999).
- Genetic data indicate naturally-spawned Chinook salmon from the Russian River are more closely related to coastal Chinook from the Eel and Klamath rivers than to inland populations (Central Valley and Santa Clara Valley). However, samples from the Eel and Russian rivers are not closely related. The Russian River

population belongs to a diverse set of coastal Chinook salmon populations (Hedgecock et al. 2003).

- Given the magnitude and duration of historic interbasin stock transfers in the Russian River, the naturally-spawning population documented in recent years may be a conglomerate of many stocks.

Although there has been some debate regarding the historical presence of Chinook salmon in the Russian River, the naturally-reproducing population is protected under the ESA. The "no production" program does not affect the local broodstock, and therefore a score of 5 is provided (Table 5-78).

Numbers of Broodstock

<u>Coho Salmon</u>

Given that the Russian River coho program is intended for short-term conservation and long-term restoration, escapement and broodstock goals are based on probabilities associated with maintaining genetic variation, and limiting demographic risks, both to the hatchery-reared and naturally-spawned components of the Russian River coho salmon population(s). In general, the escapement and broodstock goals are formulated to provide for "genetic and life-history redundancy," that is to say if a brood year is lost in the hatchery or in the stream, the surviving component should maintain sufficient genetic and life-history variation to maintain the stock. To reasonably ensure this redundancy requires that the hatchery-spawning and naturally-spawning population components are representative of one another, both genetically and in life-history characteristics, and that both components are maintained at a large size, which may be unrealistic in the short-term.

Instream spawning and broodstock goals are formulated to provide a 95 percent probability of retaining alleles occurring at a frequency of 1 percent or greater within each component of the Russian River population for a period of 5 coho salmon generations (15 years). Approximately 400 adult spawners are required in each environment to meet this goal (see FishPro and ENTRIX, Inc. 2003). Assuming a pre-spawning mortality of 5 percent, approximately 420 adults are required for instream spawning, and an additional 420 adults are required for broodstock. If juveniles are collected to form a captive brood, juvenile collections would have to be substantially larger to provide 420 adults for broodstock. Assuming a 40 percent fry-to-adult survival rate[1] in captivity (Arkush et al. 1997), approximately 588 fry would be required to achieve the adult spawning goal within the hatchery.

Using the escapement estimates of 420 spawners in each environment, and assuming an adult return rate of 0.5 and 4, respectively, for instream and hatchery-spawners, contribution to the next generation would be 210 and 1,680 adults of natural and hatchery

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[1] Juvenile collection thus far has focused on more advanced life-history stages. Fry survival estimates were used to provide a conservative estimate.

origin, respectively, with a combined N_b of 168. Ultimately, for reasons relating to artificial selection, it would be appropriate to maintain a minimum escapement goal that would allow for collection of broodstock solely from naturally-spawned adults. With a natural return rate of 0.5, this would require instream spawning by a minimum of 840 adults (which could be a combination of natural-origin and hatchery-origin individuals). Therefore, assuming 5 percent pre-spawn mortality in each environment, a minimum escapement of 1,322 adults per year is required.

Although the current Russian River coho salmon program is based on captive broodstock derived from juvenile collections, the adult escapement estimates formulated above are still valid. For example, if juveniles for the captive brood are collected solely from natural spawners, but adult escapement is low, the probability of sampling the progeny of only a few adults increases dramatically. Under this scenario, inbreeding could be expected to increase rapidly.

The numbers of broodstock used in hatchery operations has the potential to affect the wild population primarily through the mechanisms of inbreeding depression and loss of within-population diversity. However, by determining and utilizing the minimum number of broodstock necessary to maintain the genetic variability of the population, the risk of genetic effect is minimized. Table 5-79 organizes the potential range broodstock availability into five categories and provides a score of 3 for the early stages of the coho program and a score of 5 for the later stages.

Table 5-79 Numbers of Broodstock Evaluation Criteria and Scoring for Coho Salmon, Steelhead, and Chinook Salmon

Category Score	Evaluation Criteria Categories	Score
5	Maintenance of N_b necessary to maintain genetic variation with a 95% probability, in both instream and hatchery components.	Coho supplementation and captive brood (later stages). Chinook "no production" (current estimate).
4	Instream escapement > 50% N_b and hatchery broodstock > 75% N_b.	Steelhead isolated harvest.
3	Instream escapement < 50% N_b and hatchery broodstock > 50% N_b.	Coho supplementation and captive brood (earlier stages).
2	Instream escapement < 50% N_b and hatchery broodstock < 50% N_b.	
1	Instream escapement < 50% N_b.	

This assessment has estimated that a minimum of 840 wild, instream spawners is necessary if genetic variation is to be maintained over a period of 15 years. Based on the extremely low incidence of observed presence of coho salmon adults in the Russian River in recent years, it is believed there is less than half this number spawning naturally. This estimate suggests very strongly that a "no production" alternative for coho salmon would result in genetic effects to the remaining Russian River coho salmon population, and it further suggests that a supplementation program is needed to attempt recovery of the species. It may also be necessary to implement stream restoration programs to provide habitat sufficient for supporting 840 fish.

Implementation of a supplementation or captive brood program will provide an increased survival advantage of the early hatchery-reared lifestages that allows the number of spawners to be reduced to 420 while still maintaining the same threshold of genetic variation. Due to additional pre-spawning mortality that is inevitable with a captive brood program, it is estimated that 588 fry would need to be collected to achieve the minimum broodstock number. In its first year of implementation, the coho captive broodstock program collected more than 300 fry, suggesting there may still be some risk associated with genetic effect. It is expected that minimum broodstock thresholds would be achieved for both the hatchery and instream components 2 years following the first smolt release under the supplementation or captive brood production alternatives.

Steelhead

Benefit/risk analyses conducted for Russian River hatchery operations (FishPro and ENTRIX, Inc. 2003) suggest a minimum broodstock number of 210 spawners for an isolated steelhead harvest program. Escapement and broodstock goals for a Russian River steelhead program have been based on probabilities associated with maintaining genetic variation, and limiting demographic risks, both to the hatchery-reared and naturally-spawned components of the Russian River steelhead population(s). Hatchery broodstock goals are formulated to provide a 95 percent probability of retaining alleles occurring at a frequency of 1 percent or greater for a period of 3 steelhead generations (15 years). Because the proposed steelhead program is an isolated program, both the hatchery and wild populations must have the minimum number of broodstock necessary to maintain the genetic variability in each component of the population. From 1981 to 2003, the average annual adult return of steelhead to the DCFH was 2,147 fish, with a peak return of 8,100 fish during the 1994-95 season (see Section 3.8, Table 3-24, History of Steelhead Trapped at DCFH and CVFF). At the CVFF, the average annual steelhead return has been 1,991 fish, with a peak return of 3,735 fish occurring in 1996-97 (see Table 3-24). Returning steelhead numbers to both DCFH and CVFF are high enough that the probability of inbreeding within the hatchery population is low.

Adult fish counts collected through video monitoring at the Mirabel inflatable dam observed no wild steelhead during the 1999 and 2001 study periods, 36 wild steelhead during the 2002 study, and 110 wild steelhead during the 2000 study (Chase et al. 2000, 2001, 2002, 2003). Based on these observed counts, there is some uncertainty whether the Russian River system currently supports the minimum number of wild steelhead necessary to maintain diversity within the wild population. However, monitoring at the dam generally occurs over only a small portion of the steelhead run and these data are not likely to reflect the actual size of the run. Furthermore, 2000 was a dry year, and monitoring was discontinued before substantial flows occurred.

Population monitoring was conducted in Santa Rosa and Millington creeks over 3 years (Cook and Manning 2002, SCWA 2002). In general, population trends from 1999 to 2001 showed a peak in 2000, with relatively lower numbers observed in 1999 and 2001. This trend was likely affected by annual rainfall.

A conservative course of action would assume that the effective number of wild steelhead spawners occurring in the Russian River is insufficient to maintain genetic variation, and that inbreeding depression and loss of within-population diversity may be occurring in the Russian River wild steelhead population, at least until such time it can be shown that the wild steelhead population level is at or above the minimum broodstock threshold. An integrated program that would utilize naturally-spawning steelhead as broodstock could supplement the wild population and increase the number of effective spawners more quickly than without a supplementation program (evaluated in Section 5.6.5). Therefore, the risk to the genetic integrity of the wild population would be greater for an isolated program and less for an integrated program. Table 5-79 organizes the potential range of broodstock availability into five categories and provides a score of 4 for the relative risk level for the steelhead isolated harvest program.

Chinook Salmon

To formulate escapement goals for Chinook salmon in the Russian River, an estimate is made of the number of adults per year required to maintain a 95 percent probability that alleles occurring at a frequency of 1 percent or greater would be retained for a period of 15 years. An estimated minimum broodstock threshold of 242 spawners is necessary if genetic variation is to be maintained over 15 years in the naturally-spawning population (see FishPro and ENTRIX, Inc. 2003). SCWA data documented naturally-spawned Chinook salmon adults that passed the Mirabel inflatable dam, with a run-count of 1,322 during the 2000 study period, a partial run-count of 1,300 during the limited 2001 study period, and a run-count of 5,466 in 2002 (Chase et al. 2001, 2002, 2003). Based on these data, it appears likely that the Russian River system currently supports the minimum number of wild Chinook salmon necessary to maintain diversity within the wild population. These numbers suggest that the "no production" program is not likely to result in genetic effects to the remaining Chinook salmon population. Table 5-79 organizes the potential range of broodstock availability into five categories and provides a score of 5.

Broodstock Sampling and Mating Protocols

Maintaining genetic characteristics of a population during artificial propagation may be affected by the manner in which the broodstock are mated. The mating protocols recommended by NOAA Fisheries (Hard et al. 1992) were outlined in FishPro and ENTRIX, Inc. 2003. Broodstock sampling and mating protocols have the potential to affect the wild population, primarily through the mechanisms of loss of within-population diversity and outbreeding depression.

Coho Salmon

Table 5-80 organizes the potential range of sampling and mating procedures into five categories and provides a score of 2 for the early stages of the coho program and a score of 3 for the later stages.

The current status of coho salmon presence in the Russian River basin suggests that spawning aggregates may be too rare and/or too isolated to allow random mating. This condition may exacerbate the potential of sibling mating within the wild population. For the proposed supplementation and captive broodstock programs, approved protocols for broodstock sampling and mating would be implemented to ensure that the maximum genetic variability would be incorporated in the hatchery component of the overall population. A sliding schedule for mating would be established that would use diallel mating, systematic mating, or single-pair mating, depending on the number of adult returns.

Table 5-80 Broodstock Sampling and Mating Evaluation Criteria and Scoring for Coho Salmon, Steelhead, and Chinook Salmon

Category Score	Evaluation Criteria Categories	Score
5	Large naturally-spawning component allowing random mating.	Chinook "no production" (current estimate).
4	Large broodstock with pedigree mating.	
3	Large broodstock with random mating; or medium broodstock with pedigree mating.	Steelhead isolated harvest. Coho supplementation and captive broodstock (later stages).
2	Medium broodstock with random mating; or small broodstock with pedigree mating.	Coho supplementation and captive broodstock (earlier stages).
1	Random mating precluded in naturally-spawning component (due to small population size and/or isolation).	

Steelhead

Spawning protocols provide for the representation of returning fish over the complete spectrum of the spawning run (steelhead are selected systematically across the entire adult return). Jacks will be incorporated in a proportion based on their occurrence in the run. In addition, surplus eggs are taken, from which a random sample will comprise the harvest for each week. This strategy will continue to be employed to decrease the loss of genetic diversity. Table 5-80 organizes the potential range of sampling and mating procedures into five categories and provides a score of 3 for the risk level for an isolated harvest program.

The current status of steelhead in the Russian River basin suggests that spawning aggregates may be too rare and/or too isolated to allow random mating. This condition may exacerbate the potential of sibling mating within the wild population. Due to mass marking of hatchery fish, it is possible to distinguish between hatchery and wild progeny. The return of natural fish to the river where they may spawn naturally has decreased the risk of possible genetic effects due to hatchery broodstock collection.

Chinook Salmon

The current status of Chinook salmon in the Russian River basin should allow for random mating, although it is unknown whether the Russian River supports distinct or isolated spawning aggregates having population sizes less than the recommended minimum broodstock number. This condition may exacerbate the potential of sibling mating within the wild population. Table 5-80 organizes the potential range of sampling and mating procedures into five categories and provides a program score of 5.

Rearing Techniques

Naturalized Rearing Environments

One approach for decreasing the potentially deleterious effects of artificial selection is implementation of the Natural Rearing Enhancement System (NATURES) described by Maynard et al. (1996). While implementation of these methods may not increase survival per se, implementation of NATURES methods might be useful as a means to avoid cryptic side effects of artificial selection.

Rearing techniques have the potential to affect the wild population primarily through the mechanism of artificial selection. Environmental conditions in the hatchery that attempt to simulate natural conditions are likely to reduce typical differences between hatchery and natural fish. Low-density rearing indices (between 0.30 and 0.40 pounds of fish per cubic foot [lbs/cf] of water per inch of fish length) are recommended by NOAA Fisheries as a means to maximize adult return (Flagg et al. 2000).

Although “natural” rearing methods have not been significantly adopted at DCFH or CVFF, routine operations of these facilities already include some of the recommended procedures: broodstock selection, shaded ponds at DCFH, volitional release at CVFF, imprinting at both facilities, health monitoring, release timing coordinated with smoltification and lunar phase, and daily exercise encountered during cleaning operations when water velocities are much greater than the normal condition. Photoperiods of outdoor rearing facilities (containing salmonids ranging in size from fingerlings to smolts) follow the natural environment at both facilities.

Table 5-81 organizes the potential range of rearing techniques into five categories and provides each program with a score of relative-risk level. Rearing pond densities are usually managed to maintain a maximum density of 2.25 lbs/cf. For the steelhead isolated harvest program, the score is 2. At a minimum, it is expected that coho supplementation and captive brood programs would operate under low-density conditions, and that NATURES features would be added as data become more conclusive regarding their benefit to minimizing artificial selection and increasing adult return. Rearing ponds for coho salmon to be released will be managed so they do not exceed a maximum density of

2.25 lbs/cf. Lower densities will be maintained whenever possible. Rearing pond densities for the captive broodstock will be managed so they do not exceed a maximum density of 1.0 lbs/cf. For the coho program, the score is 3. Because there is no hatchery captivity, there is no risk for Chinook salmon.

Table 5-81 Rearing Techniques Evaluation Criteria and Scoring for Coho Salmon, Steelhead, and Chinook Salmon

Category Score	Evaluation Criteria Categories	Score
5	No hatchery captivity.	Chinook "no production."
4	Low-density rearing with multiple NATURES features.	
3	Low-density rearing.	Coho supplementation, captive brood.
2	High-density rearing with NATURES features.	Steelhead isolated harvest.
1	High-density rearing.	

Fish Health

As compared to the low fish densities observed in wild populations, the higher density conditions of artificial propagation increases the risk of prevalence of fish pathogens that are present naturally in the watershed. Pathogens that are capable of establishing carrier states and can be transmitted vertically with gametes, such as bacterial kidney disease and bacterial coldwater disease, are of particular concern for supplementation programs because of the potential to create a disproportionate carrier rate among hatchery-reared fish. The potential effects extend into the future by perpetuation of the pathogens by vertical transmissions from the F1 (first generation) hatchery-reared fish to their F2 (second generation) naturally-spawning progeny (Hedrick 2002).

As a means of minimizing the risk of disease transfer to the wild population, CDFG conducts routine fish health management operations at all of its facilities, including DCFH and CVFF. These operations include the following fish health protocols recommended by NOAA Fisheries (Hard et al. 1992):

- Adults contributing gametes are regularly sampled for pathogens of common salmonid diseases.
- Incubation facilities are sterilized before gametes are transported to them.
- Gametes brought into the facility are isolated from all others and the resulting fertilized eggs disinfected. To avoid horizontal disease transfer, progeny should be isolated by full-sib family until cleared though pathological testing and then monitored regularly during culture.

- Infected fish are isolated and treated. However, it should be recognized that some incipient level of disease is natural and also probably essential for immunological readiness for episodic outbreaks.

The DCFH hatchery water supply is treated to minimize the transfer of pathogens from the natural population. Details regarding DCFH and CVFF fish health practices are outlined in the HGMPs (FishPro, Inc. and ENTRIX, Inc. 2003). The facilities maintain good track records in managing routine fish diseases. Also, recent changes in CDFG policy regarding importation of stocks have resulted in a condition with minimal likelihood of affecting listed stocks through disease.

Release Strategies

Release strategies have the potential to affect the wild population through several ecological interactions (Nickelson 2003; Flagg et al. 2000). Operational release strategies that reduce interactions of juvenile hatchery fish with wild fish include consideration of the age of releases, release size, acclimation and volitional releases, and selection of release locations.

<u>Coho Salmon</u>

In the BO for Permit 1067 (NMFS 2001c), the preferred release strategy is noted to be the release of smolts, with a second preference for the release of fingerling. A mortality of 90 percent for fingerling before they reach the yearling stage is commonly assumed for wild populations. If sufficient numbers of coho salmon are produced to allow for release of both smolts and fingerling, then a tagging regime will be implemented that allows comparison between the two release strategies. The first fish release is anticipated in spring 2004. Release protocols for both fingerling and smolt releases will be developed.

The size of a juvenile fish has been shown to affect its ability to compete, escape predators, and survive the ocean phase of its life-history. Stocking with hatchery-reared juveniles of a similar size to naturally-spawned individuals may decrease the probability of competition and predation, and minimize selection pressures that may accompany a clear difference in size. Coho salmon fingerling and smolts will be reared to a size that mimics the size of natural fish of the same age to minimize the risk of predation and competition with natural fish upon release.

Given that it may be impossible to protect between-population diversity within the Russian River Basin (because population sizes are small), managers will seek to avoid erosion of this component of variation on a larger geographic scale. To do so, the highest possible degree of homing fidelity will be maintained for coho salmon released in the Russian River. Coho salmon released as smolts will be acclimated in net-pens at the release site for at least 30 days prior to their release. The net pens will be monitored daily during this period.

Releases of fish for supplementation purposes should occur only in locations where the habitat capacity exceeds the requirements of the local, naturally-spawning population. Release of coho salmon into restored rearing habitat where coho salmon have been extirpated or where abundance is low would minimize negative competitive interactions. To minimize competition between hatchery-reared and naturally-spawned fish, fingerling and smolt releases will occur where there are no known populations of wild fish. Releases will occur in five different streams, which will reduce the potential for attracting predators that might occur with a larger release group in a single location. Monitoring and evaluation over time can provide data to guide future release strategies as coho salmon abundance changes.

Table 5-82 organizes the potential range of release strategies into five categories and provides each a score of 3 for the coho program. Habitat conditions will be surveyed for multiple years prior to juvenile releases to determine appropriate release locations and densities. While the development of acclimation facilities to allow volitional release in these locations is preferred, the limited access to streams in the Lower Russian River watershed may greatly restrict the opportunity for such facilities.

Table 5-82 Release Strategies Evaluation Criteria and Scoring for Steelhead and Coho Salmon

Category Score	Evaluation Criteria Categories	Score
5	No hatchery releases.	Chinook “no production.”
4	Volitional smolt releases into areas with known habitat carrying-capacity.	Steelhead isolated harvest (CVFF).
3	Direct smolt releases into areas with known habitat carrying-capacity.	Steelhead isolated harvest (DCFH). Coho supplementation, captive brood.
2	Volitional smolt releases into areas with unknown habitat carrying-capacity.	
1	Direct smolt releases into areas with unknown habitat carrying-capacity.	

<u>Steelhead</u>

It is generally assumed that hatchery-reared fish released as smolts soon migrate to the ocean, and they consequently exhibit little likelihood of competing for freshwater resources utilized by naturally-spawned fingerling rearing within the system (Flagg and Nash 1999; Pascual et al. 1995). The steelhead isolated harvest program will release only smolts.

Juvenile trapping studies conducted at the Mirabel inflatable dam indicate wild steelhead smolts are predominantly in the age 2+ class, whereas hatchery steelhead are 1+ smolts that have recently been released from the hatchery (Chase et al. 2001). It would be beneficial to track the migration of hatchery steelhead smolts downstream from Mirabel dam to determine whether they continue directly to the mouth and enter the ocean as age 1+ fish, or whether they stay within the lower Russian River to rear for an additional year.

The size of a juvenile fish is an indicator of the habitat it is likely to inhabit. Age 0+ steelhead prefer shallow, quiet water a few feet from shore, whereas age 1+ steelhead are found in deeper, faster water towards the center of the stream (Flagg et al. 2000). Steelhead are typically 140 to 160 mm in length before they begin to smolt and migrate to the sea (Flagg et al. 2000).

Screw-trap studies conducted at the Mirabel inflatable dam during the 2000 sampling season used the measured fork length (FL) to classify the fish into 0+, 1+, and 2+ age classes. The weekly average fork length of 0+ steelhead increased from 43.7 mm during the first week of sampling (April 8) to 84.0 mm during the last week (June 24). Six of the eight steelhead observed in the age 1+ class were trapped in June, and they ranged in size between 120 and 136 mm. The age 2+ steelhead were trapped predominantly in late April and exhibited a size range of 142 to 238 mm, with an average length of 172 mm (Chase et al. 2001).

The release size for fish from the existing Russian River isolated harvest program is 5 fish per pound, which for steelhead equates to a typical length of 210 mm. While this is within the observed size range of wild steelhead smolts in the 2+ age class, it is somewhat larger than the average size for the 2+ smolts. The proposed program will classify fish as yearling smolts when they approach 4 to 5 fish per pound. Although the hatchery steelhead are released as 1+ fish, they are in the same size range as wild steelhead smolts in the 2+ age class. To minimize the risk of ecological interactions from the isolated harvest production, the program employs release strategies that increase the spatial and temporal separation between hatchery and wild fish. The hatchery steelhead are reared to the same approximate size as wild steelhead smolts and released in the spring to mimic the natural fish emigration strategy and encourage rapid downstream migration to the estuary, thereby minimizing the risk of ecological interaction with listed fish. Additionally, releases are coordinated with lunar cycles, because this is believed to benefit from surges in thyroxine that occur in the fish on a monthly basis. To minimize potential effects related to predation, hatchery fish generally are not released immediately into spawning or rearing habitat. Releases take place only on Dry Creek and the East Fork Russian River, leaving additional rearing habitat in the basin unaffected. DCFH and CVFF each conduct releases in approximately 12 separate batches spread over a 3-month period, which is believed to reduce the potential for attracting predators. Straying is minimized through release of progeny at or very close to the rearing facility. Steelhead released at CVFF are imprinted first for a minimum of 30 days and releases are volitional. Table 5-82 organizes the potential range of release strategies into five categories and provides each a score of 3 for the DCFH and 4 for the CVFF.

Chinook Salmon

Because no releases of Chinook salmon would occur, there is no risk for the Chinook salmon “no production” program.

Duration in Hatchery Captivity

The duration of hatchery captivity has the potential to affect the wild population primarily through the mechanism of artificial selection. Simply stated, with a longer period of duration, more life-history stages may be subjected to artificial selection, and more traits may become susceptible to the effects of artificial selection.

Table 5-83 organizes the anticipated range of hatchery captivity into five categories and provides a score of 3 for the risk level for a steelhead isolated harvest program and a coho supplementation program. Captive broodstock programs, which derive spawners from hatchery-reared individuals collected as juveniles, have a greater risk of accumulation of artificially selected phenotypes than standard supplementation programs, which derive broodstock from naturally-spawned adult returns. Therefore, the score for the captive broodstock program is 2. Without hatchery captivity in any life-history stage, there is no risk for the Chinook salmon "no production" program (Table 5-83).

Table 5-83 Duration in Hatchery Captivity Evaluation Criteria and Scoring by Program

Category Score	Evaluation Criteria Categories	Score by Program Alternative
5	No hatchery captivity.	Chinook "no production."
4	Hatchery captivity through fry life-stage.	
3	Hatchery captivity through smolt life-stage.	Steelhead isolated harvest. Coho supplementation.
2	Hatchery captivity through adult life-stage.	Coho captive brood.
1	Hatchery captivity for repeated generations.	

Harvest Management

Harvest management has the potential to affect the wild population primarily through the mechanism of unintended harvest bycatch of the non-target population. To reduce the potential for deleterious effects, it is essential to monitor the effects of harvest on listed populations. Budget limitations have precluded the ability of CDFG to conduct harvest surveys in recent years, but funding may soon be available for such activities (R. Gunter, CDFG, pers. comm. 2002).

The isolated harvest program allows a fishery within the basin for hatchery-reared steelhead. Harvest of coho salmon is prohibited within the Russian River basin. While this strategy minimizes direct fishing mortality of coho salmon, indirect effects such as hooking mortality and harassment may still occur. There are no current estimates for incidental harvest levels of coho salmon within the Russian River. Table 5-84 organizes the potential range of harvest management decisions into five categories and provides a score of relative risk level. Because harvest will be allowed on steelhead, the score is 2 for all three listed salmonid species.

Table 5-84 Harvest Management Evaluation Criteria and Scoring

Category Score	Evaluation Criteria Categories	Score
5	No harvest allowed within basin.	
4	Harvest allowed on one or more non-listed, distinguishable/marked population, with comprehensive surveys to assess harvest, angler effort, and bycatch effects to wild population.	
3	Harvest allowed on one or more non-listed, distinguishable/marked population, with moderate survey activity.	
2	Harvest allowed on one or more non-listed, distinguishable/marked population, with minimal survey activity.	Co, St, Ch
1	No limits on harvest.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook Salmon

5.6.2 Benefits Assessment of Proposed Fish Facility Programs on Listed Species

5.6.2.1 Reduction in Short-Term Risk of Extinction

Hatchery supplementation programs have an egg-to-adult survival advantage that can help reduce short-term extinction risks faced by natural populations. For very small populations, demographic and environmental variability generally pose the greatest short-term risks, but genetic risks such as inbreeding can also be important concerns, especially in populations that persist at small size for some time. Both a standard supplementation and captive broodstock coho program can help to reduce these risks, resulting in reduced extinction risk and conservation of genetic diversity.

A main objective of the coho captive broodstock program for the Russian River is to prevent extirpation of Russian River coho salmon. The 1995 status review (NMFS 1995) found that the Central California Coast Coho ESU was in danger of extinction. A status review update for coho salmon for the Central California Coast ESU (NMFS 2001b) analyzed presence-absence data and population trend data between 1989 and 2000, and found lower abundances in the 1990s than in the mid-to-late 1980s. (The 1996 and 1997 year classes were strong; conclusions were based largely on data collected in those years.) The values of coho salmon replacement rates (CSR) were less than 1 for 126 of 229 observations, indicating a significantly ($p = 0.0045$) higher likelihood that abundance decreased rather than increased. The Central California Coast Coho ESU was determined to presently be in danger of extinction. Supplementation programs would reduce this risk of extinction.

All available data suggest that the Russian River coho salmon spawning aggregate is at risk from demographic stochasticity and the loss of genetic variation. If the Russian River coho salmon aggregate survives unaided until the factors contributing to its decline are mitigated, recovery would likely be hindered by the loss of genetic variation.

A status review update for the California Coastal Chinook ESU (Busby et al. 1999) found that coastal California streams support small, sporadically monitored populations of fall-run Chinook salmon, and that population trends are mixed. In general, trends tend to be more negative along the south coast (Eel, Mattole, and Russian rivers). Monitoring of index areas in the Mattole and Russian river basins indicates declining trends in abundance, except for increasing abundance at the CVFF from 1992 to 1998 (Busby et al. 1999). Previous CDFG estimates for Chinook salmon were 100 to 500 adults. However, recent data from video monitoring at the Mirabel Inflatable Dam indicate a current naturally-reproducing population in the Russian River in excess of 1,300 adults (Chase et al. 2001; 2002). Long-term trends are not available. Estimates of absolute population abundance are not available for most populations in this ESU.

The available data suggest that the Russian River Chinook salmon naturally-spawning aggregate may not necessarily be at risk from demographic stochasticity and the loss of genetic variation.

5.6.2.2 Increase in Speed of Recovery

Factors that speed recovery of depleted populations are important for several reasons, both biological and social. For example, rapid recovery: 1) minimizes the time a population spends at low abundances, and at high risk; and 2) minimizes the time over which the reduction of healthy populations produce a risk to economic and social effects. Supplementation programs can likely result in healthy, self-sustaining populations only if at least one of the following conditions are met: 1) factors responsible for the original decline are addressed concurrently with supplementation; or 2) supplementation helps to propel a population out of a stable but depressed state into a higher equilibrium abundance. Supplementation efforts within the Russian River watershed, combined with ongoing habitat restoration efforts, would speed recovery through increased population abundance for coho salmon.

The Chinook salmon "no production" alternative would eliminate potential risks associated with hatchery supplementation. If monitoring shows that population trends are declining or that genetic variation is limited, supplementation efforts within the Russian River watershed could speed recovery through increased population abundance for Chinook salmon (see Section 5.6.5).

5.6.2.3 Restoration of Ecosystem Processes

Coho supplementation and captive broodstock programs may contribute to the restoration of a functional ecosystem within the Russian River by increasing the abundance of native coho salmon. Clearly, the link between the ocean and fresh water provided by salmon migration is necessary for proper functioning of the ecosystems to which they are native. Salmon act as a conduit for the movement of marine nutrients and are a necessary food source for many native species.

Salmon also play an important role with regard to gravel recruitment, which affects stream morphology and in turn affects the habitat of other native species. Construction of redds promotes gravel recruitment, and may change the dimensions and stability of a streambed or channel. For example, redd construction along the banks of a stream may widen the channel. A wider streambed may be less prone to erosion and scouring during flood events, and hence may provide a more stable environment for aquatic biota.

5.6.3 Summary of Effects and Benefits of Proposed Programs on Listed Species

Steelhead

The proposed (and current) DCFH and CVFF isolated harvest program reflects a commitment to minimize effects on listed fish populations. Procedures for waste treatment demonstrate continuous compliance with regulated discharge standards for water quality. Broodstock protocols regarding source, spawning numbers, and mating procedures follow recommended procedures to minimize genetic effects within the hatchery population. The program's release strategies take practical measures to isolate the hatchery population from the wild population as a means of minimizing genetic interaction as well as ecological effects from predation and competition. The facilities maintain good track records in their ability to manage routine fish diseases, and recent changes in policy regarding importation of stocks have resulted in a condition with minimal likelihood of affecting listed stocks through disease. Rearing is conducted at moderate densities, and several NATURES techniques are incorporated in efforts to minimize domestication. Harvest management policies have implemented mass marking of all steelhead releases and a selective harvest of hatchery fish as a practical approach to minimizing harvest effects on wild populations.

In general, there is a low risk of adverse effects to listed populations. However, there is a low risk for some potential effects to occur. For example, hatchery fish may prey on listed natural fish because they are released at a larger size, and there may be more fishing pressure on natural fish than would have occurred if hatchery fish were not being released. Also, because the numbers of wild steelhead may be below the viable population threshold, the lack of a hatchery supplementation program to increase abundance of the wild population may in fact contribute to increased potential for inbreeding depression and loss of within-population diversity in the wild population.

Key benefits of the isolated harvest program include contributions toward mitigation requirements, and contributions to the steelhead harvest fishery.

Coho Salmon

Fish production for the purpose of supplementation differs from traditional production or mitigation by preserving demographic, genetic, and ecological characteristics of natural populations (Hard et al. 1992). Unfortunately, most literature dealing with salmon focuses on the effects of production or mitigation hatcheries on natural populations. The effects of supplementation-oriented programs would be quite different.

This analysis lacks the numerical data necessary to conclude that Russian River coho salmon stocks are not vulnerable to adverse effects that may result from the implementation of a standard supplementation or captive brood program. However, given the available presence/absence data for coho salmon, the Russian River spawning aggregate of the Central California Coast Coho ESU may be at risk of extinction. Overall, a properly maintained and managed supplementation program, such as the captive broodstock program implemented by CDFG in 2001, offers the opportunity to address many of the uncertainties surrounding the role of hatcheries in conservation. If the preference of the fish management agencies is to preserve the genetic variability found within the Russian River spawning aggregate, conservation actions must proceed even in the face of scientific uncertainty. The results of the analysis suggest that a supplementation-oriented coho program would be invaluable in avoiding further genetic degradation of the Russian River aggregate in addition to providing a buffer against demographic risks of low adult returns.

Chinook Salmon

Given the available short-term data for Chinook salmon, the Russian River spawning aggregate of the California Coastal Chinook ESU does not appear to be at immediate genetic risk. Until additional data determine the status of naturally-spawning Russian River Chinook salmon, the "no production" alternative is the preferred program.

Table 5-85 provides a summary of the operational risk scores for the proposed coho salmon, steelhead, and Chinook salmon programs.

Table 5-85 Summary of Scores for Operational Risk Categories for Steelhead, Coho, and Chinook Programs

Operational Risk Category	Steelhead Isolated Harvest	Coho Supplementation	Coho Captive Brood	Chinook "no production"
Source of Broodstock	3	4	4	5
Numbers of Broodstock	4	3	3	5
Broodstock Sampling and Mating	3	3	3	5
Rearing Techniques	2	3	3	5
Release Strategies	4	4	4	5
Duration in Hatchery Captivity	3	3	2	5
Harvest Management	2	2	2	2

Notes: 1. A score of 5 presents the least risk to the wild population.
2. A score of 1 may result in unacceptable conditions under the ESA.

5.6.4 Synthesis of Effects and Benefits across Listed Species

Hatchery programs implemented for one species may have effects on other listed species. Introduction of hatchery fish has the potential to increase risks associated with inter-species predation and competition. Harvest management for one species may affect the wild populations of other species through unintended harvest bycatch of the non-target population.

The extent of competition/predation risk depends not only on specific hatchery practices, but also on the extent of habitat overlap for various life-history stages. Coho salmon, steelhead, and Chinook salmon have evolved to coexist with a certain amount of niche partitioning. For example, coho salmon spawn earlier in the year and larger young-of-the-year coho salmon can therefore out-compete steelhead young-of-the-year in their preferred pool habitat. Where steelhead and coho salmon juveniles coexist, steelhead are more likely to utilize run/riffle habitat. Steelhead, however, are more likely than coho salmon to successfully utilize a wider range of habitat types in the Russian River.

If abundances (naturally-spawned or hatchery-population components) are increased for one species, it may increase the inter-species risk of competition and predation. Some of the same hatchery practices that reduce the risk for intra-species interactions can help minimize this risk. By releasing hatchery fish at smolt size, the residence time for hatchery fish in the freshwater environment is minimized. It is recommended that any hatchery program release smolts in the same size range of wild smolts, and volitional release and acclimation facilities can help reduce straying. By releasing fish for supplementation purposes only into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population, the risk of deleterious interactions can be reduced.

Differences in adult spawning times are likely to minimize potential competitive interactions for naturally-spawning salmonids. The greatest amount of habitat and temporal overlap is likely to occur for the juvenile rearing life-history stage. Because Chinook salmon in the Russian River have an ocean life-history stage, and because they generally utilize low-gradient tributaries and the upper mainstem, the opportunity for interaction is less extensive than for steelhead and coho salmon. (Chinook salmon spawning was observed well downstream of Dry Creek in November 2002, but this is not believed to be the main spawning area [S. White, SCWA, pers. comm. 2002b]). However, if a supplemented population of one species exceeds habitat capacity, it may affect naturally-spawned components of other species.

Harvest management may affect the wild population primarily through unintended harvest bycatch of the non-target population. If harvest is allowed on one or more distinguishable/marked populations (such as hatchery steelhead) with no harvest surveys, the risk to all listed species increases.

Restoration programs may contribute to the restoration of a functional ecosystem within the Russian River by increasing the abundance of native salmonid species. Restoration of ecosystem function is likely to benefit target and non-target species.

5.6.5 Future Alternative Fish Facility Programs

Most California hatcheries, including the DCFH and CVFF, were established for the purposes of mitigation and enhancement. With the listing of salmonid species under the ESA, efforts are underway in the Russian River to utilize the hatchery facilities to supplement naturally-spawning populations and aid in the recovery of listed species. A key question that remains to be answered is whether hatchery production can provide sustainability for naturally-spawning populations. As new information on the status of Russian River populations becomes available from the recovery planning, the DCFH and CVFF hatchery facilities may be able to contribute to recovery efforts in ways that differ from the proposed programs.

Benefit/risk analyses were developed to evaluate the relative risks and benefits of alternative hatchery programs (FishPro and ENTRIX, Inc. 2003). According to this analysis, it may be beneficial to implement future alternative hatchery programs if monitoring and evaluation indicate they are warranted.

Benefits and risks of hatchery alternatives are difficult to weigh, given the need for further studies. Furthermore, tradeoffs between benefits and risks could occur, such as:

- As divergence between hatchery and naturally-spawning populations are reduced, risks related to increased ecological interactions in the wild are increased.
- As broodstock numbers are increased, the risk of amplifying the genetic traits of the founding broodstock may be reduced, but the risk of domestication may increase.
- If diversity is increased through interbreeding in a hatchery environment, there could be an initial cost in terms of reduced fitness.

Within the Russian River, limited information on the status of salmonid populations makes it difficult to quantify potential benefits and risks. The M&E Plan identifies many of these data needs and outlines a process to collect data (FishPro and ENTRIX, Inc. 2003). Until these data are available, strategies can be implemented to reduce the potential risks associated with hatchery programs.

This section presents an analysis of a Chinook salmon supplementation program, based on an assumption that new data show the Russian River population of Chinook salmon to be below the viable population threshold.

In addition, this section presents an analysis for steelhead production referred to as integrated harvest. This alternative differs from the isolated harvest program evaluated earlier, primarily through the use of wild steelhead broodstock rather than using returning hatchery-reared fish. This program would create a significant reduction in the risk of genetic effects to the wild population. The implementation of this program assumes that the wild population of steelhead is stable or increasing, which again is dependent on the results of population studies that are likely to be completed through recovery planning efforts.

A future alternative program for coho salmon is not considered in this analysis, because it is believed that the proposed coho captive broodstock or supplementation programs are the only programs that will reduce the risk of extirpation of Russian River coho salmon, and it will likely be many years before the naturally-spawning coho population is self-sustaining.

5.6.5.1 Evaluation of Effects of Future Alternative Fish Facility Programs on Listed Fish Species

Sources of Broodstock

Based on present knowledge and as a matter of preference, it is assumed that both the steelhead integrated harvest alternative and the Chinook supplementation alternative will collect all broodstock from the supply of wild adult fish returning to the Russian River basin. However, the selection of a broodstock source ultimately will be dictated by availability. Within the constraints of availability, the following priorities are recommended:

1. Naturally-spawned broodstock collected in the most unbiased manner possible from the local target population(s), provided that collection of broodstock does not endanger the population.

2. Naturally-spawned adults from the nearest watershed, provided that collection of broodstock does not endanger the population. If several such sources are available, managers may wish to choose the location(s) that have a high probability of maintaining transfers, and that most closely match the environmental characteristics of the Russian River and tributaries. Further, when possible, managers may wish to consider using cryopreserved milt from local sources, if/when available, to fertilize the eggs of transferred females.

3. Hatchery-reared adults collected in the most unbiased manner possible from the local population. (This option is available immediately for the steelhead integrated harvest alternative. However, for the Chinook supplementation alternative, this option will be feasible only after 2 years of supplementation using wild Chinook salmon for broodstock, as the F1 hatchery-reared progeny of the broodstock begin to return to their release streams.)

To assess which of these three broodstock source priorities will least affect listed species, it is assumed that studies regarding both genetic structure and productivity will have been completed for the steelhead and Chinook salmon population(s) of the Russian River and surrounding basins. Based on this assumption, the following process will help determine which of the three broodstock sources will be used:

- Genetic analysis of Russian River population indicates acceptable levels of genetic variation, and population abundance of the Russian River population is above the viable population threshold:

  Steelhead: Supplementation using Priority 1 broodstock only at a level necessary to replace wild broodstock collected for harvest production. (This is the program assumed and described in this future alternative evaluation.)

  Chinook: Supplementation unnecessary.

- Genetic analysis of Russian River population indicates acceptable levels of genetic variation, and population abundance of the Russian River population is below the viable population threshold:

  Steelhead: Supplementation using Priority 1 broodstock to replace wild broodstock collected for harvest production as well as to increase naturally-spawning population.

  Chinook: Supplementation using Priority 1 broodstock. (This is the program assumed and described in this future alternative evaluation.)

- Genetic analysis of Russian River population indicates unacceptable levels of genetic variation:

  Steelhead and Chinook: Supplementation using Priority 2 broodstock.

- If there are no acceptable Priority 2 broodstock available, the steelhead and Chinook salmon supplementation program will utilize Priority 3 broodstock only until Priority 2 or Priority 1 broodstock become available.

Table 5-86 organizes the recommended priorities for broodstock source into five categories, and provides each category with a score of relative risk level. By utilizing local Russian River stocks as the source of broodstock, the source of genetic material in the first-generation hatchery component is presumably identical to that of the wild population. Based on the experience gained from the Russian River coho salmon recovery program, it is assumed that determination of abundance and productivity of Russian River steelhead and Chinook salmon populations will be completed in the near future while wild adults remain available for broodstock collection. Should it be determined that supplementation is desirable, implementing a supplementation program using broodstock collected from the wild would be significantly more cost-effective than having to develop and maintain a captive broodstock. This effects analysis therefore assumes that program implementation will be initiated with the local broodstock source.

Numbers of Broodstock

The benefit/risk analyses evaluating Russian River fish facility operations (FishPro and ENTRIX, Inc. 2003) describes the science behind the development of escapement and broodstock goals based on probabilities associated with maintaining genetic variation and limiting demographic risks, both to the hatchery-reared and naturally-spawned components for any supplementation program population(s). The escapement and broodstock goals are formulated to provide for “genetic and life-history redundancy”; i.e., if a brood year is lost, either in the hatchery as a result of catastrophic failure or in the stream as a result of a random environmental event, the surviving component should maintain sufficient genetic and life-history variation to maintain the stock.

Table 5-86 Source of Broodstock Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score for Program Alternatives
5	Local broodstock source (target stock), collected in the most unbiased manner possible.	Steelhead integrated harvest, Chinook supplementation
4	Naturally-spawned broodstock source from the nearest watershed; or a combination of naturally-spawned and hatchery-reared broodstock from the local source.	
3	Hatchery-reared broodstock source from the local or nearest watershed; or naturally-spawned broodstock source from within the same ESU.	
2	Hatchery-reared broodstock source from within the same ESU; or naturally-spawned broodstock source from a different ESU.	
1	Hatchery-reared broodstock source from a different ESU.	

Steelhead Integrated Harvest Program

As described in FishPro and ENTRIX, Inc. (2002), it is estimated that 200 steelhead adults is the minimum number of broodstock required to maintain a 95 percent probability that alleles occurring at a frequency of 1 percent or greater will be retained for a period of 15 years, assuming an N_b/N ratio of 0.2. Allowing for a prespawning mortality of 5 percent increases the minimum broodstock number to 210. Based on the historic performance of DCFH and CVFF steelhead production, a minimum of 269 adults must be spawned to achieve the release goals of 500,000 smolts. Therefore, minimal risk of loss of genetic diversity exists in fish produced for the harvest program, due to the numbers of broodstock required for production.

For the integrated harvest program, a minimum of 269 wild broodstock will be collected from the Russian River basin each year. To assure that this practice does not affect the productivity of wild population, the program will release approximately 70,000 smolts each year (out of the 500,000 total smolt production) into Russian River tributaries that are the expected source of the wild steelhead broodstock. Since these smolts are the progeny of wild Russian River steelhead, presumably there is no genetic difference between the fish released and their wild cohorts. These fish will be marked as hatchery-reared fish and will be subject to harvest pressure, but any successful recruits returning to the release stream will be left in stream for natural spawning. Based on an estimated smolt-to-adult return (SAR) of 1.0 percent (per DCFH and CVFF records), and assuming a harvest rate of 15 percent, approximately 595 adult F1 steelhead are expected to spawn naturally in the release stream. Assuming a current productivity of 0.5 for the naturally-spawning population, these F1 adults will result in the return of approximately 298 F2 naturally-spawned and naturally-reared adult steelhead. With a wild broodstock collection goal of 269 adults, the supplementation portion of the integrated harvest program provides a slight cushion in the numbers of naturally-spawned fish produced to compensate for the annual number collected from the environment. Since this number once again exceeds the minimum number of broodstock necessary to maintain genetic diversity, minimal risk to the naturally-spawned population is caused by the number of fish used for broodstock.

Chinook Salmon Supplementation Program

FishPro and ENTRIX, Inc. (2002) describes that, assuming an N_b/N ratio of 0.2, a minimum in-stream escapement goal of 726 adults per year is recommended for the Chinook supplementation program. A subset of this goal is the ability to collect 242 naturally-spawned adults as broodstock for the hatchery component of the program, leaving at least 478 adults (comprised of both hatchery-reared and naturally-spawned individuals) remaining as broodstock for in-river spawning. These broodstock collection goals meet or exceed the minimum recommended numbers for maintaining genetic diversity in each population component, and thereby minimize any potential genetic effect to the listed population. However, current estimates of population performance—including an estimated productivity of 0.5 for the naturally-spawning population and an estimated SAR of 0.2 percent (assuming a slightly improved SAR over the estimated 0.15 percent experienced with the previous DCFH Chinook production program—indicate possible periodic difficulty in achieving the minimum escapement goal. Monitoring and assessment of population performance measures will be completed annually to assess whether Chinook supplementation release numbers should be adjusted upward to achieve the instream escapement goals.

Evaluation

It is assumed that implementation of the steelhead integrated harvest program and Chinook salmon supplementation will occur only after completion of relevant studies relating to abundance and population growth rate in the Russian River basin. Supplementation will be implemented only if it can be demonstrated that wild broodstock are available for collection in numbers greater than the minimum broodstock size, and that removal of these broodstock from the environment will not reduce the wild population to a level less than the minimum effective population size. Table 5-87 organizes the potential range broodstock availability into five categories, and provides a score of 5 for the relative risk level for both the steelhead integrated harvest program and the Chinook supplementation program.

Table 5-87 Numbers of Broodstock Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	Maintenance of N_b necessary to maintain genetic variation with a 95% probability, in both instream and hatchery components.	Steelhead isolated harvest, Chinook supplementation
4	Instream escapement > 50% N_b and hatchery broodstock > 75% N_b.	
3	Instream escapement < 50% N_b and hatchery broodstock > 50% N_b.	
2	Instream escapement < 50% N_b and hatchery broodstock < 50% N_b.	
1	Instream escapement < 50% N_b.	

Broodstock Sampling and Mating Protocols

The following broodstock sampling and mating protocols will be implemented as recommended by NOAA Fisheries (Hard et al. 1992):

- A primary goal of the sampling program should be to obtain a representative sample for use as broodstock while allowing a representative sample to remain in the wild.

- Sampled adults should represent the entire run with regard to size, age, and other measurable phenotypic characters that may have adaptive value.

- If the number of available natural spawners is large enough to permit a large sample to be taken, random sampling (sampling without regard to measurable characters) is likely to ensure that the natural population is represented adequately in the broodstock. If the number of natural spawners is too small to permit a large sample, however, systematic sampling on the basis of measurable characters (particularly run timing and size and age at maturity) may be required to achieve adequate representation.

- The mating design should be chosen to equalize as much as possible the contributions of parents to the next breeding generation. This procedure will maximize N_e (effective population) for a given number of breeders and minimize the effects of selection.

- If possible, parents should be mated at random with regard to phenotypic characters that may have adaptive value (e.g., age and size at maturity).

- Mating design may include matings of single pairs, matings of single females to overlapping pairs of males, or factorial designs involving crosses between all possible parents. A modified single-pair design is generally preferable to simple matings of single pairs because it reduces risk of loss due to infertile males. A factorial design, assuming that the realized variance in progeny number is small, increases the probability of unique genetic combinations in the progeny. However, a complete factorial design will generally be feasible only with very small populations, since the benefits rapidly decrease (and the logistical difficulties rapidly increase) with increasing numbers of adults.

- Gametes from different individuals should not be mixed prior to fertilization, since mixing would affect the contribution of some individuals if variability existed in the potency of milt.

- In very small populations, a fraction of the milt from each male should be cryopreserved to maintain a "sire bank." These gametes can provide additional male "breeders" in years when the number of available males is low. Moreover, such crosses between brood years can help to preserve long-term genetic variability if severe population bottlenecks have been frequent or persistent.

Broodstock sampling and mating protocols have the potential to affect the wild population, primarily through the mechanisms of loss of within-population diversity and outbreeding depression, as discussed in FishPro and ENTRIX, Inc. 2003. It is assumed that the status of the wild steelhead and Chinook salmon populations in the Russian River basin would allow for random mating, should either of the alternative programs be approved for implementation. However, it is unknown whether the Russian River supports distinct or isolated spawning aggregates having population sizes less than the recommended minimum broodstock number, and this condition may exacerbate the potential of sibling mating within the wild broodstock collected for spawning. For the proposed steelhead integrated harvest program and Chinook supplementation program, approved protocols for broodstock sampling and mating would be implemented to ensure that the maximum genetic variability would be incorporated in the hatchery component of the overall population. Table 5-88 organizes the potential range of sampling and mating procedures into five categories, and provides a score of 3 for the risk level for an isolated harvest program.

Table 5-88 Broodstock Sampling and Mating Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	Large naturally-spawning component allowing random mating.	
4	Large broodstock with pedigree mating.	
3	Large broodstock with random mating; or medium broodstock with pedigree mating.	Steelhead integrated harvest, Chinook supplementation
2	Medium broodstock with random mating; or small broodstock with pedigree mating.	
1	Random mating precluded in naturally-spawning component (due to small population size and/or isolation).	

Rearing Techniques

Naturalized Rearing Environments

As described by FishPro and ENTRIX, Inc. (2002), the degree to which artificial selection might be expected to result in the divergence of phenotypes among hatchery-reared adults or juveniles is related to the difference in selective regimes between the hatchery and natural environment. The NATURES described by Maynard et al. (1996) attempts to decrease the potentially deleterious effects of artificial selection by minimizing selective differences between the two environments. The NATURES approach utilizes naturally-colored raceways and rearing ponds, natural substrates, rearing unit covers, subsurface feeding, and lower rearing densities (among other factors) in an effort to mimic natural conditions in the hatchery. While implementation of these methods may not increase survival per se, implementation of NATURES methods might be useful as a means of avoiding cryptic side effects of artificial selection.

The existing DCFH rearing facilities incorporate NATURES features by providing covers and shading for the outdoor rearing units. CVFF includes the NATURES feature of volitional release. Both facilities, however, were designed assuming higher densities than is commonly preferred by today's standards. With the bulk of production for the steelhead integrated harvest program aimed at providing harvest opportunity, it is assumed that continued use of existing rearing facilities and methods will provide adequate performance and survival for a successful program. For a Chinook salmon supplementation program, however, in which the fish are expected to adapt to the natural population, it is assumed that new facilities will be provided to allow low density rearing. Table 5-89 indicates a score of 2 for the steelhead integrated harvest alternative, and a score of 3 for the Chinook supplementation program.

Table 5-89 Rearing Techniques Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	No hatchery captivity.	
4	Low density rearing with multiple NATURES features.	
3	Low density rearing.	Chinook supplementation
2	High density rearing with NATURES features.	Steelhead integrated harvest
1	High density rearing.	

Fish Health

Potential effects relating to fish health for the future alternative programs are identical to those described in Section 5.6.1.3 for the proposed programs. It is assumed that adherence to fish health management guidelines would minimize risk of disease transfer from the hatchery to wild populations to an undetectable level. It is further assumed that implementation of either the steelhead integrated harvest program or the Chinook supplementation program would include an element in the monitoring and evaluation plan to measure the incidence of pathogens in supplementation release streams.

Release Strategies

Release strategies have the potential to affect the wild population through several ecological interactions. Operational release strategies include age of releases, release size, acclimation, and volitional releases and selection of release locations.

Steelhead Integrated Harvest Program

Release strategies recommended for the potential future integrated harvest program are nearly identical to those of the proposed isolated harvest program. As a consequence, the potential effects of the integrated program are very similar to those described in Section

5.6.1.3 for the isolated program. The potential effects are repeated here for convenience, with minor variations as relevant for the integrated harvest program.

It is generally assumed that hatchery-reared fish released as smolts soon migrate to the ocean, and they consequently exhibit little likelihood of competing for freshwater resources utilized by naturally-spawned fingerling rearing within the system. The steelhead integrated harvest program will release only smolts.

Juvenile trapping studies conducted at Mirabel dam indicate wild steelhead smolts are predominantly in the 2+ age class, whereas hatchery steelhead are 1+ smolts that have recently been released from the hatchery (Chase et al. 2001, 2002, 2003). It has been recommended as part of the existing steelhead isolated harvest program to track the migration of hatchery steelhead smolts downstream from Mirabel dam to determine whether they continue directly to the mouth and enter the ocean as age 1+ fish, or whether they stay within the lower Russian River to rear for an additional year. Depending on the results of these efforts, it may be desirable to consider increasing the release age of steelhead smolts for the proposed integrated harvest program. However, rearing the fish for an additional year would require a tremendous increase in the amount of space and flow at the DCFH and CVFF facilities.

The size of a juvenile fish is an indicator of the habitat it is likely to inhabit. Age 0+ steelhead prefer shallow quiet water a few feet from shore, whereas Age 1+ steelhead are found in deeper, faster water towards the center of the stream (Flagg et al. 2000). Steelhead are typically at least 140 to 160 mm in length before they begin to smolt and migrate to sea (Flagg et al. 2000).

Screw trap studies conducted at Mirabel inflatable dam during the 2000 sampling season used the measured fork length to classify the fish into 0+, 1+, and 2+ age classes. The weekly average fork length of 0+ steelhead increased from 43.7 mm during the first week of sampling (April 8) to 84.0 mm during the last week (June 24). Six of the eight steelhead observed in the 1+ age class were trapped in June, and ranged in size from 120 to 136 mm. The Age 2+ steelhead were trapped predominantly in late April and exhibited a size range of 142 to 238 mm, with an average length of 172 mm (Chase et al. 2001).

The release size for the existing Russian River isolated harvest program is five fish per pound, which for steelhead equates to a typical length of 210 mm. While this is within the observed size range of wild steelhead smolts in the 2+ age class, it is somewhat larger than the average size for the 2+ smolts. The future integrated harvest program will classify fish as yearling smolts when they approach four to five fish per pound. Although the hatchery steelhead are released as 1+ fish, they are in the same size range as wild steelhead smolts in the 2+ age class.

Release locations for the integrated harvest program are intended to increase the spatial and temporal separation between the harvest component and broodstock supplementation component. Releases of the harvest component will take place only on Dry Creek and the East Fork Russian River, leaving the remainder of rearing habitat in the basin unaffected. Straying is minimized through release of progeny at or very close to the rearing facility.

Steelhead releases at CVFF will be imprinted first for a minimum of 30 days and releases are volitional. Release locations for the broodstock supplementation component will occur in the same stream(s) from which broodstock are collected. Table 5-90 organizes the potential range of release strategies into five categories, and provides each a score of 3 for the DCFH harvest and supplementation components and 4 for the CVFF harvest component.

Table 5-90 Release Strategies Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	No hatchery releases.	
4	Volitional smolt releases into areas with known habitat carrying capacity.	Steelhead integrated harvest (CVFF)
3	Direct smolt releases into areas with known habitat carrying capacity.	Steelhead integrated harvest (DCFH), Chinook supplementation
2	Volitional smolt releases into areas with unknown habitat carrying capacity.	
1	Direct smolt releases into areas with unknown habitat carrying capacity.	

Chinook Supplementation Program

Different life-stages of fish may experience differing levels of resource limitation, depending on the time and duration of resource utilization. Even in a supplementation program with intended interaction when the adults return, there may be a benefit to fish release practices that minimize temporal overlap in the hatchery-reared and naturally-spawned components, suggesting a preference for smolt releases over fingerling releases. Hatchery-reared fish released as smolts soon migrate to the ocean, and they consequently exhibit little likelihood of competing for freshwater resources utilized by naturally-spawned fingerling reared within the system. It is assumed that the Chinook supplementation program will release 0+ smolts in the spring.

Screw trap studies conducted at Mirabel inflatable dam measured the fork length of fish that were trapped. Chinook salmon emigrate through the Wohler Pool at an average of 90 mm FL (range approximately 35 mm to 140 mm) (Chase et al. 2002). During the 2000 sampling season, the weekly average fork length of 0+ Chinook salmon increased from 81 mm during the first week of sampling (April 8) to 105 mm during the last week (June 24) (Chase et al. 2001). Chinook salmon averaged approximately 35 to 40 mm FL during the first few weeks of their life in 2002, then quickly grow to approximately 80 mm by mid-April. A similar size is recommended for the Chinook salmon supplementation releases as a means of mimicking the life-history characteristics of the wild population.

The release location for the Chinook supplementation program will occur only in locations where the habitat capacity exceeds the requirements of the local naturally-spawning population. This indicates the importance for resource managers to identify the area of habitat utilization for various life-stages. Release of Chinook salmon into restored rearing habitat where Chinook salmon have been extirpated or abundance is low, would minimize negative competitive interactions. Monitoring and evaluation over time can provide data to guide future release strategies as Chinook salmon abundance changes.

Table 5-90 organizes the potential range of release strategies into five categories and indicates a score of 3 for the Chinook supplementation program. It is assumed that habitat conditions will be surveyed for multiple years prior to juvenile releases to determine appropriate release locations and densities. While the development of acclimation facilities to allow volitional release in these locations would be preferential, the limited access to streams in the Russian River watershed may greatly restrict the opportunity for such facilities.

Duration in Hatchery Captivity

The duration of hatchery captivity has the potential to affect the wild population primarily through the mechanism of artificial selection. The rate and extent to which phenotypic, genetic and behavioral divergence may occur within the hatchery environment is largely dependent on selective pressure within the hatchery, and the number of generations the hatchery-reared stock has been isolated from the donor stock. Typically, divergence requires many generations.

Many sources of artificial selection that could occur in a hatchery can be avoided, such as assuring a representative sampling of all available broodstock. However, it is not possible to avoid all sources of artificial selection. For example (as discussed in FishPro and ENTRIX, Inc. 2003), culling eggs or juveniles exhibiting a high titer for bacterial kidney disease may result in inadvertent selection against those individuals possessing a natural resistance to the disease. All things being equal, one would expect the number of diverged traits and the magnitude of divergence to increase with the duration of captivity. Table 5-91 organizes the anticipated range of hatchery captivity into five categories and provides both the steelhead integrated harvest alternative and the Chinook supplementation program with a score of 3, since both alternatives utilize wild broodstock and release the progeny as smolts.

Table 5-91 Duration in Hatchery Captivity Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	No hatchery captivity.	
4	Hatchery captivity through fry life-stage.	
3	Hatchery captivity through smolt life-stage.	Steelhead integrated harvest, Chinook supplementation
2	Hatchery captivity through adult life-stage.	
1	Hatchery captivity for repeated generations.	

Harvest Management

Harvest management has the potential to affect the wild population primarily through the mechanism of unintended harvest bycatch of the non-target population. To reduce the potential for deleterious effects, it is essential to monitor the effects of harvest on listed populations.

It is proposed that the steelhead integrated harvest program allow a fishery within the basin for the hatchery-reared steelhead, even though these fish are the progeny of wild, listed steelhead. Harvest of coho and Chinook salmon is prohibited within the Russian River basin. All hatchery-reared fish will be mass-marked, and it is assumed that harvest surveys will provide a measure of both the direct take (of hatchery-reared steelhead) and indirect take (bycatch of all wild salmon and steelhead) for all listed species. The production goals for the supplementation component of the steelhead integrated harvest program should then be updated periodically to reflect the observed harvest rate as it pertains to the broodstock return goals. While this strategy minimizes direct fishing mortality of coho salmon, steelhead, and Chinook salmon, indirect effects such as hooking mortality and harassment may still occur. Table 5-92 organizes the potential range of harvest management decisions into five categories, and provides a score of 3 on the assumption that routine harvest surveys will be implemented prior to approval of the steelhead or Chinook salmon program alternatives.

Table 5-92 Harvest Management Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	No harvest allowed within basin.	
4	Harvest allowed on one or more non-listed, distinguishable/marked population, with comprehensive surveys to asses harvest, angler effort, and bycatch effects to wild population.	
3	Harvest allowed on one or more non-listed, distinguishable/marked population, with moderate survey activity.	Steelhead integrated harvest, Chinook supplementation
2	Harvest allowed on one or more non-listed, distinguishable/marked population, with minimal survey activity.	
1	No limits on harvest.	

5.6.5.2 Benefits Assessment of Future Alternative Programs on Listed Species

Reduction in Short-Term Risk of Extinction

Hatchery supplementation programs have an egg-to-adult survival advantage that can help reduce short-term extinction risks faced by natural populations. For very small populations, demographic and environmental variability generally pose the greatest short-term risks, but genetic risks such as inbreeding can also be important concerns, especially in populations that persist at small size for some time. The Chinook supplementation program can help reduce these risks, resulting in reduced extinction risk and conservation of genetic diversity. (The steelhead integrated harvest program assumes that the productivity of the wild steelhead population is equal to or greater than 1 and therefore not at risk of extinction; the supplementation component provides replacement fish for collected broodstock, ensuring no decrease in the wild population due to this practice.)

A status review update for the California Coastal Chinook ESU (Busby et al. 1999) found that coastal California streams support small, sporadically-monitored populations of fall-run Chinook salmon, and that population trends are mixed. In general, trends tend to be more negative along the south coast (Eel, Mattole, and Russian rivers). Recent monitoring of index areas in the Mattole and Russian river basins indicates declining trends in abundance, except for increasing abundance at the CVFF from 1992 to 1998 (Busby et al. 1999). Previous CDFG estimates for Chinook salmon were 100 to 500 adults, but recent data from video monitoring at the Mirabel Inflatable Dam indicate a current naturally-reproducing population in the Russian River in excess of 1,300 adults (Chase et al. 2001; 2002). Long-term trends are not currently available. However, it is assumed the Chinook supplementation alternative will not be implemented until long-term trends in abundance and the level of genetic variation in the naturally-spawning component of the population indicate that such a program would be beneficial.

Increase in Speed of Recovery

The Chinook supplementation program, combined with ongoing habitat restoration efforts, would speed recovery through increased population abundance for Chinook salmon.

Restoration of Ecosystem Processes

The Chinook supplementation alternative could contribute to the restoration of a functional ecosystem within the Russian River by increasing the abundance of native Chinook salmon. Clearly, the link between the ocean and fresh water provided by salmon migration is necessary for proper functioning of the ecosystems to which they are native. Salmon act as a conduit for the movement of marine nutrients and are a necessary food source for many native species.

5.6.5.3 Summary of Effects and Benefits of Future Programs

Steelhead Integrated Harvest

The steelhead integrated harvest program assumes that population abundance and growth rate studies for wild Russian River steelhead have been completed as part of the recovery planning efforts, and that the results of these studies indicate a population level greater than the viable population threshold and a stable or increasing trend in population. The main objective of changing from an isolated to an integrated harvest program is to minimize the genetic divergence between the hatchery-reared and naturally-spawning steelhead populations, while maintaining a smolt release program to support a recreational fishery and satisfy mitigation agreements. Production guidelines presented recommended measures to minimize potential genetic and ecological risks relating to broodstock collection and mating protocols, rearing and release methods, and harvest management.

Chinook Supplementation

The Chinook supplementation program assumes that population abundance and growth rate studies for Russian River Chinook salmon have been completed as part of the recovery planning efforts, and that the results of these studies indicate a population level less than the viable population threshold and a decreasing trend in population. Assuming further that, according to genetic studies, Russian River Chinook salmon are representative of the California Coastal Chinook ESU, a supplementation-oriented Chinook salmon program would be invaluable as a means of avoiding further genetic degradation of the Russian River aggregate in addition to providing a buffer against demographic risks of low adult returns. Production guidelines presented provide recommended measures to minimize potential genetic and ecological risks relating to broodstock collection and mating protocols, rearing methods, and release strategies.

Table 5-93 provides the operational risk scores for the proposed future steelhead integrated harvest and the Chinook supplementation programs.

Table 5-93 Summary of Scores for Operational Risk Categories for Future Alternative Steelhead and Chinook Programs

Operational Risk Category	Steelhead Integrated Harvest	Chinook Supplementation
Source of Broodstock	5	5
Numbers of Broodstock	5	5
Broodstock Sampling and Mating	3	3
Rearing Techniques	3	2
Release Strategies	3	3
Duration in Hatchery Captivity	3	3
Harvest Management	3	3

Notes: 1. A score of 5 presents the least risk to the wild population.
2. A score of 1 may result in unacceptable conditions under the ESA.

5.6.6 Summary of Effects and Benefits of Proposed and Future Programs

The DCFH and CVFF were established with legal obligations for mitigation and enhancement goals for coho salmon, steelhead, and Chinook salmon. NOAA Fisheries has noted that hatchery production of Pacific salmon may be consistent with the purposes of the ESA in two situations: 1) when the hatchery production facilitates the recovery of a listed species; or 2) when the enhancement of unlisted populations does not impede the recovery of a listed species or compromise the viability or distinctiveness of an unlisted species (Hard et al. 1992). A conservation hatchery program is being considered to examine the role such a program may provide in reducing effects to listed species and to aid in their recovery.

Steelhead

Summary of Risks

Conclusions regarding the relative risk of the proposed steelhead isolated harvest program and the future alternative integrated harvest program operations are summarized in Table 5-94. By determining and utilizing the minimum number of broodstock necessary to maintain the genetic variability of the population, the risk of genetic effect (primarily inbreeding depression and loss of within-population diversity) can be minimized. There is some uncertainty about whether the Russian River system supports the minimum number of wild steelhead necessary to maintain genetic diversity. This suggests that the isolated harvest program has the potential to result in genetic effects to the remaining Russian River steelhead population.

Table 5-94 Summary of Scores for Operational Risk Categories for Proposed and Future Alternative Steelhead Programs

Operational Risk Category	Isolated Harvest	Integrated Harvest
Source of Broodstock	3	4-5
Numbers of Broodstock	4	4-5
Broodstock Sampling and Mating	3	2-3
Rearing Techniques	2	2
Release Strategies	4	3
Duration in Hatchery Captivity	3	3
Harvest Management	2	2

Notes: 1. A score of 5 presents the least risk to the wild population.
2. A score of 1 may result in unacceptable conditions under the ESA.

The risk of loss of within-population diversity and outbreeding depression may be minimized by appropriate broodstock sampling and mating protocols. The total steelhead spawning aggregate in the Russian River appears to be greater than the minimum broodstock threshold level, but individual tributary populations may be too rare or isolated to allow random mating. Until adequate numbers of wild steelhead exist to assure that broodstock mining would not affect the broodstock threshold level of the remaining local stock, it is recommended that a mix of hatchery-reared and naturally-spawned broodstock be utilized for the integrated harvest program.

By decreasing the selective gradient between the hatchery and instream environment, the risk of artificial selection may be minimized. It is proposed that, at a minimum, a supplementation program would operate under low-density rearing conditions, and that NATURES features would be added as appropriate.

To reduce potential effects related to competition and predation, the hatchery program would release smolts in the same size range of wild smolts, and volitional release and acclimation would help reduce straying. By releasing fish primarily into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population, competitive interactions can be reduced.

The risk of artificial selection in a hatchery increases with duration of captivity; more life-history stages may be subjected to artificial selection and more traits may become susceptible. Supplementation integrated harvest and isolated harvest programs that rear fish through the smolt lifestage have a higher risk.

Harvest management may affect the wild population primarily through unintended harvest bycatch of the nontarget population. If harvest is allowed on one or more non-listed, distinguishable/marked populations (such as hatchery steelhead) with no harvest surveys, the risk to listed species increases.

Summary of Benefits

Potential benefits of steelhead hatchery programs may include reduction in short-term risk of extinction, increase in speed of recovery, restoration of ecosystem processes and cultural and social benefits (including harvest).

Increased egg-to-adult survival experienced with hatchery supplementation programs may reduce short-term extinction risks faced by natural populations. For very small populations, demographic and environmental variability pose the greatest short-term risks, but genetic risks such as inbreeding can also be important. The supplementation alternative can help reduce these risks, resulting in reduced extinction risk and conservation of genetic diversity.

Supplementation could help speed recovery through increased population abundance for steelhead. However, factors responsible for the original decline must be addressed.

By increasing the abundance of native steelhead, a vital component of the ecosystem would be restored. Additional benefits associated with implementation of hatchery programs could include fulfillment of legal mandates (e.g., existing mitigation requirements), reducing uncertainties with regard to ecosystem conditions, public education, and increased harvest opportunity.

A properly maintained and managed harvest supplementation program offers the opportunity to address many of the uncertainties surrounding the role of hatcheries in conservation. To preserve the genetic variability found within the Russian River spawning aggregate, the integrated harvest supplementation program may be the most appropriate, even in the face of scientific uncertainty.

Coho Salmon

Summary of Risks

Conclusions regarding the relative risks of the proposed coho production program are summarized in Table 5-95. By utilizing local stocks as the source of broodstock, the source of genetic material in the first-generation hatchery component of the captive broodstock program is presumably identical to that of the wild population, reducing the risk of outbreeding depression and the loss of within-population or between-population diversity.

Table 5-95 Summary of Scores for Operational Risk Categories for Proposed Coho Program

Operational Risk Category	Standard Supplementation	Captive Brood
Source of Broodstock	4	4
Numbers of Broodstock	3	3
Broodstock Sampling and Mating	3	3
Rearing Techniques	3	3
Release Strategies	4	4
Duration in Hatchery Captivity	3	2
Harvest Management	2	2

Notes: 1. A score of 5 presents the least risk to the wild population.
2. A score of 1 may result in unacceptable conditions under the ESA.

An estimated minimum of 840 wild, instream spawners is needed to maintain genetic variation over a period of 15 years (the estimated time-frame to achieve objectives). Based on the extremely low incidence of observed presence of coho salmon adults in the Russian River in recent years, less than half this number may be spawning naturally. This suggests that the proposed coho program is important to the recovery of the species.

The current status of coho salmon in the basin suggests that spawning aggregates may be too rare and/or too isolated to allow random mating, and therefore a risk of inbreeding exists. For the supplementation and captive broodstock programs, protocols for broodstock sampling and mating could ensure that the maximum genetic variability will be incorporated into the hatchery component of the overall population.

By decreasing the selective gradient between the hatchery and instream environment, the risk of artificial selection may be minimized. At a minimum, it is expected that coho supplementation and captive brood programs would operate under low-density rearing conditions, and that NATURES features would be added as appropriate.

To reduce potential effects related to competition and predation, it is recommended that any hatchery program release smolts in the same size range of wild smolts, and volitional release and acclimation can help reduce straying. It is recognized that the limited access to streams on private property in the Russian River watershed may greatly restrict the opportunity for acclimation/volitional release facilities. By releasing fish for supplementation purposes only into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population, competitive interactions can be reduced. Monitoring and evaluation over time can provide data to guide future release strategies as coho salmon abundance changes.

The risk of artificial selection in a hatchery increases with duration of captivity. Captive broodstock programs, which derive spawners from hatchery-reared individuals collected as juveniles, have a greater risk of accumulation of artificially-selected phenotypes than standard supplementation programs that derive broodstock from naturally-spawned adult returns.

Harvest management may affect the wild population primarily through unintended harvest bycatch of the non-target population. If harvest is allowed on one or more non-listed, distinguishable/marked populations (such as hatchery steelhead) with no harvest surveys, the risk to listed species increases.

<u>Summary of Benefits</u>

Potential benefits of hatchery programs may include reduction in short-term risk of extinction, increase in speed of recovery, restoration of ecosystem processes, and cultural and social benefits.

The main objective of the captive broodstock and supplementation programs for the Russian River is to prevent extirpation of Russian River coho salmon. All available data suggest that the Russian River coho salmon spawning aggregate is at risk from demographic stochasticity and the loss of genetic variation. If the coho salmon aggregate survives unaided until factors contributing to its decline are mitigated, recovery would likely be hindered by the loss of genetic variation.

Supplementation and captive broodstock programs can likely result in healthy, self-sustaining populations only if at least one of the following conditions are met: 1) factors responsible for the original decline are addressed concurrently; or 2) supplementation helps to propel a population out of a stable but depressed state into a higher equilibrium abundance. Supplementation would speed recovery of coho salmon.

Supplementation and captive broodstock programs may contribute to the restoration of a functional ecosystem within the Russian River by increasing the abundance of native coho salmon. Additional benefits associated with implementation of hatchery programs could include fulfillment of legal mandates (e.g., existing mitigation requirements), reducing uncertainties with regard to ecosystem conditions, public education, and increased harvest opportunity (following delisting).

Overall, a properly maintained and managed supplementation program, such as the Russian River pilot captive broodstock program implemented by CDFG in 2001, offers the opportunity to address many of the uncertainties surrounding the role of hatcheries in conservation. The results of this analysis suggest that a supplementation-oriented coho program will be invaluable as a means to avoid further genetic degradation of the Russian River aggregate, in addition to providing a buffer against demographic risks of low adult returns.

Chinook Salmon

Summary of Risks

Conclusions regarding the relative risk of the future alternative supplementation program as compared to the proposed "no production" program are summarized in Table 5-96. By determining and utilizing the minimum number of broodstock necessary to maintain the genetic variability of the population, the risk of genetic effect (primarily inbreeding depression and loss of within-population diversity) can be minimized. It appears that the Russian River system supports the minimum number of wild Chinook salmon necessary to maintain genetic diversity. This suggests that the "no production" alternative may result in the least genetic effect to the remaining Russian River Chinook salmon population, since all other programs would divert wild Chinook salmon from the natural-spawning population to an extent proportional to the benefit derived by reducing the potential for divergence between the hatchery-reared and wild populations.

Table 5-96 Summary of Scores for Operational Risk Categories for Proposed and Future Alternative Chinook Salmon Programs

Operational Risk Category	No Production	Supplementation
Source of Broodstock	5	4-5
Numbers of Broodstock	5	4-5
Broodstock Sampling and Mating	5	3
Rearing Techniques	5	3
Release Strategies	5	3
Duration in Hatchery Captivity	5	3
Harvest Management	2	2

Notes: 1. A score of 5 presents the least risk to the wild population.
2. A score of 1 may result in unacceptable conditions under the ESA.

The risk of loss of within-population diversity and outbreeding depression may be minimized by appropriate broodstock sampling and mating protocols. It is unknown whether spawning aggregates in the Russian River are too isolated to allow random mating. For the proposed supplementation program, approved protocols for broodstock sampling and mating would be implemented to ensure that the maximum genetic variability would be incorporated in the hatchery component of the overall population.

By decreasing the selective gradient between the hatchery and instream environment, the risk of artificial selection may be minimized. It is proposed that, at a minimum, the supplementation program would operate under low density rearing conditions, and that NATURES features would be added as appropriate.

To reduce potential effects related to competition and predation, it is recommended that any hatchery program release smolts in the same size range of wild smolts, while volitional release and acclimation can help reduce straying. By releasing fish for supplementation purposes only into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population, competitive interactions can be reduced.

The risk of artificial selection in a hatchery increases with duration of captivity; more life-history stages may be subjected to artificial selection and more traits may become susceptible. Supplementation programs that rear fish through the smolt life-stage have a higher risk than the “no production” alternative.

Harvest management may affect the wild population primarily through unintended harvest bycatch of the non-target population. If harvest is allowed on one or more non-listed, distinguishable/marked populations (such as hatchery steelhead) with no harvest surveys, the risk to listed species increases under any alternative.

<u>Summary of Benefits</u>

Potential benefits of hatchery programs may include reduction in short-term risk of extinction, increase in speed of recovery, restoration of ecosystem processes, and cultural and social benefits.

By increasing the abundance of native Chinook salmon, a vital component of the ecosystem would be restored. Additional benefits associated with implementation of hatchery programs could include fulfillment of legal mandates (e.g., existing mitigation requirements), reducing uncertainties with regard to ecosystem conditions, public education, and increased harvest opportunity.

Supplementation could help speed recovery through increased population abundance for Chinook salmon. However, factors responsible for the original decline (if one exists) must be addressed. Recent data from video monitoring at the Mirabel Inflatable Dam indicate a current naturally-reproducing population in the Russian River in excess of 1,300 adults (Chase et al. 2001; 2002). Based on the current short-term abundance data for Chinook salmon, the Russian River spawning aggregate of the California Coastal Chinook ESU does not appear to be at immediate genetic risk and indeed may be a self-sustaining population. Until additional data determine the status of naturally-spawning Russian River Chinook salmon, the “no production” alternative may be the preferred action.

5.6.7 Summary of Effects and Benefits

5.6.7.1 Proposed and Future Fish Production Programs

The DCFH and CVFF have been operated under established mitigation and enhancement goals for coho salmon, steelhead, and Chinook salmon. Under the proposed project, a conservation hatchery program would be implemented for coho salmon to aid in their recovery. The isolated harvest program for steelhead would continue, with an option for a future integrated harvest program. Chinook salmon production would be halted, with an option for a future integrated supplementation program.

5.6.7.2 Coho Salmon

The main objective of the captive broodstock and supplementation programs for the Russian River is to prevent extirpation of Russian River coho salmon. Given the low numbers of coho salmon, it is clear that the Russian River spawning aggregate is at risk of extinction. A properly maintained and managed supplementation program, as begun by CDFG's Russian River pilot captive broodstock program implemented in 2001, would be invaluable as a means to avoid further genetic degradation of the Russian River aggregate. It would also increase coho salmon populations in the Russian River and provide a buffer against demographic risks of low adult returns.

Potential risks to the Russian River coho salmon population associated with the proposed hatchery programs include reduction of genetic viability in coho salmon stock, competition with hatchery-produced coho or steelhead, and predation by hatchery steelhead. By using local coho salmon stocks as the source of broodstock and implementing a carefully crafted breeding program, the captive broodstock and supplementation programs can substantially reduce the risk of loss of genetic diversity. New rearing techniques, including low-density rearing conditions and the use of NATURES features would reduce artificial selection, improving the fitness of hatchery outplants. Potential competitive interactions among naturally-spawned coho salmon and coho from the captive breeding program would be reduced by releasing coho into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population.

5.6.7.3 Steelhead

The proposed steelhead isolated harvest program would contribute toward mitigation requirements and sustain a recreational steelhead fishery while minimizing effects on listed fish populations. As with the coho salmon program, hatchery protocols would be implemented to minimize genetic and ecological risks to the naturally-spawning steelhead population. Appropriate broodstock sampling and mating protocols would be implemented. Programs that rear fish through the smolt life-stage have a higher risk of artificial selection than those that release smaller fish. As described for coho salmon, new rearing techniques would reduce the risk of artificial selection. To reduce possible effects related to potential competitive interactions or predation, the hatchery program would release steelhead smolts in the same size range as wild smolts, and volitional release and acclimation would help reduce straying.

A future alternative integrated harvest program, which would use wild steelhead broodstock rather than only hatchery-reared fish, would significantly reduce the risk of genetic effects to the naturally-spawning population. The integrated harvest program may be implemented if needed to protect genetic integrity of steelhead in the Russian River. Potential benefits may also include reduction in short-term risk of extinction and increase in speed of recovery. By increasing the abundance of native steelhead, a vital component of the ecosystem would be restored. However, factors responsible for the original decline must be addressed.

5.6.7.4 Chinook Salmon

This BA currently proposes a “no production” program. Based on the current short-term abundance data for Chinook salmon, the Russian River spawning aggregate of the California Coastal Chinook ESU does not appear to be at immediate genetic risk, and indeed it may be a self-sustaining population. This suggests that the “no production” alternative may result in the least genetic effect to the remaining Russian River Chinook salmon population.

A supplementation program could be implemented if population trends indicate that this action is needed to prevent the Russian River population of Chinook salmon from declining below the viable population threshold. Potential benefits of future supplementation programs include reduction in short-term risk of extinction, increase in speed of recovery, and restoration of ecosystem processes. By increasing the abundance of native Chinook salmon, a vital component of the ecosystem would be restored. Supplementation could help speed recovery through increased population abundance for Chinook salmon. However, factors responsible for the original decline (if one exists) must be addressed.

The loss of within-population diversity and outbreeding depression may be minimized by appropriate broodstock sampling and mating protocols. For the proposed future supplementation program, approved protocols for broodstock sampling and mating would be implemented. The future Chinook salmon program would incorporate new rearing techniques to reduce artificial selection, low-density rearing, and volitional-release programs to reduce competition and predation pressures on the local naturally-spawning population. Fish would be released into locations where the habitat capacity exceeds the requirements of the naturally-spawning population.

5.7 SUMMARY OF EFFECTS AND BENEFITS

5.7.1 FLOOD CONTROL OPERATIONS, WATER STORAGE, AND SUPPLY OPERATIONS

5.7.1.1 Operation of Coyote Valley and Warm Springs Dams

Channel Geomorphology

Flood control operations at dams can reduce the magnitude of peak-flood discharges in downstream areas. Adequate flows are periodically needed to maintain channel geomorphic conditions by mobilizing the streambed and transporting sediments. Such flows are necessary to flush fine sediments from the streambed and provide suitable spawning and rearing conditions for salmonids. However, if flood releases are of sufficient magnitude and frequency to regularly scour redds, spawning may be negatively affected. Ideally, there would be a balance between periodic mobilization of the streambed, transport of sediment and sediment deposition, and stability of spawning gravels.

Flood control operations are not likely to have a substantial effect on salmonids or their habitat downstream of Coyote Valley Dam. To minimize bank erosion, flood control operations are often timed so that reservoir outflows are an insignificant portion of the total streamflow at Hopland or Cloverdale. The flood regime on the Upper Reach Russian River, which can be influenced by operations at Coyote Valley Dam, would continue to be adequate to maintain channel geomorphic conditions. Steelhead and Chinook salmon redd scour would continue to occur more frequently in the Middle Reach Russian River than in the Upper Reach, but this is due to accretion from tributaries rather than flood control operations.

Flood control operations at Warm Springs Dam would not contribute significantly to prolonged flows above the threshold that initiates streambank instability and erosion in most years in Dry Creek. Flood control operations at Warm Springs Dam generally result in a reasonably good balance between streambed mobilization and spawning gravel stability for successful reproduction of steelhead and Chinook salmon. Coho salmon habitat may be scoured too frequently to provide for good reproduction in Dry Creek. Given the present geomorphology of Dry Creek, scour of coho salmon spawning gravels would likely occur even in the absence of flood control operations.

Flow Recessions

Releases from the dams would be ramped down during the receding limb of a flood hydrograph (winter season). Releases from the dams would also be ramped down or would cease during inspection and maintenance activities (summer season). Downstream habitat potentially may be subjected to flow recessions and dewatering, and juvenile salmonids may be stranded.

On the mainstem Russian River, ramping effects during flood control operations would be unlikely to strand fish. At the Forks, as in the past, there would usually be flow from the mainstem Russian River to attenuate ramping effects, and the backwater effect on the East Fork would attenuate stage changes. The stranding fish in Dry Creek would be unlikely given the ramping rates that would be used at Warm Springs Dam and the bypass flow capability of 25 cfs.

During annual inspections and repairs at Coyote Valley Dam under baseline conditions, there was a risk of stranding juvenile fish. Under the proposed project, annual inspections and repairs at Coyote Valley Dam would be scheduled between July 15 and October 15 to minimize the potential for stranding fry, the most vulnerable life-history stage. Low-flow ramping rates at Coyote Valley Dam would be reduced from 50 cfs to 25 cfs/hr, and bypass flows would be provided, creating substantially improved conditions for steelhead and Chinook salmon juveniles in the mainstem downstream of the Forks.

Under the proposed project, annual inspections and dam maintenance activities at Coyote Valley and Warm Springs dams would be unlikely to affect populations of listed fish species.

5.7.2 DIVERSION AND TRANSMISSION FACILITIES

Under baseline conditions, the potential to affect rearing fry and juveniles, and outmigrating smolts, was identified at the Mirabel and Wohler diversion facilities. The proposed project would minimize the potential for impingement of fry and juvenile salmonids during the diversion season by upgrading the fish screens at the diversion facilities to meet NOAA Fisheries criteria. Upgraded fish screens at the Wohler diversion would also reduce the potential for entrainment of juvenile fish into the Wohler infiltration ponds.

During flood flows, the levees at the Mirabel and Wohler infiltration ponds occasionally overtop and fish can be entrained. The levees at the Mirabel infiltration ponds would not overtop often, so the risk of entrapment would be low. Under baseline conditions, the risk at the Wohler ponds was higher. Under the proposed project, regrading the Wohler infiltration ponds and providing a continual connection to the river would reduce the potential to trap salmonids. Fish rescues would be provided in the Wohler and Mirabel infiltration ponds as needed. Although a few fish may be entrained in the Mirabel or Wohler ponds, the risk to the population under the proposed project would be low, substantially improved over baseline conditions.

Recent studies by SCWA and NOAA Fisheries conducted at the inflatable dam under baseline conditions suggest that the dam may delay downstream passage of steelhead smolts. These studies also suggest that Chinook salmon migration is not negatively affected currently. Creating a notch in the crest of the dam during the smolt outmigration period would improve smolt passage. Furthermore, integration of the intake structure and upstream end of the fish ladder would result in more effective use of river flows to create sweeping velocities and enhance downstream passage. These modifications would likely to benefit young coho salmon, steelhead, and Chinook salmon that encounter the diversion during downstream migration.

Inflation of the inflatable dam has the potential to cause flow recessions that strand fish. Deflation of the dam results in upstream stage changes and dewatered habitat that has a low risk of stranding juvenile fish. The risk to juvenile salmonids would continue to be highest during inflation of the dam, when river flows would be lower, and young fish might be stranded in riffles downstream of the dam. However, dam inflation and deflation occurs infrequently (on average, flow recessions would occur about three times per year).

The inflatable dam would continue to change habitat in the Wohler Pool from a combination of run/riffle/pool habitat to primarily pool habitat. This might reduce food transport during the early summer months when steelhead need it most to support increased metabolism. Summer water temperatures would be increased only slightly above natural warming through Wohler Pool, and high summer water temperatures would likely limit summer rearing habitat in this part of the mainstem. Pool habitat that would favor warmwater predator communities would be created above the inflatable dam. However, data from fish sampling indicate that few of the predators sampled in this habitat are large enough to be a significant threat to juvenile salmonids. Although alterations in habitat occur in Wohler Pool, they would not be expected to have substantial effects on steelhead rearing or coho and Chinook salmon migration.

Operations and maintenance activities that use materials for water treatment or for facility maintenance would carry out under specified permits and restrictions and by trained personnel. Although a catastrophic spill (e.g., diesel fuel) could have significant effects over a local area, with spill prevention and control measures in place, the risk of such a scenario occurring be low.

Accidental spills from the water transmission system could introduce chlorinated water to streams in the watershed. SCWA has added dechlorination baskets and alerts to each of the valves that could spill, thereby eliminating the risk to salmonids.

5.7.3 FLOW AND ESTUARY MANAGEMENT

The current flow regime in both the Russian River and Dry Creek is determined by the requirements of D1610, water supply needs, and flood control operations. A flow/habitat study conducted jointly by USACE, SCWA, NOAA Fisheries, CDFG, and ENTRIX, Inc., determined that the current flow regime is higher than optimal in both streams for the summer rearing lifestages of coho salmon, steelhead, and Chinook salmon (ENTRIX, Inc. 2003b).

SCWA developed the Flow Proposal based on the study findings and the desire to improve habitat conditions for these species, while continuing to meet water demands now and in the future at the water demand levels projected in the WSTSP. The focus of the Flow Proposal is to provide the best possible conditions during the summer months, when conditions would be most limiting to salmonids and when the effects of the project would be most pronounced. During the winter months, streamflows are largely the result of rainfall and runoff from unregulated tributaries, and project operations would be less important in determining streamflow. An additional objective is to allow the Estuary to remain closed during the summer months, thereby providing more stable habitat conditions and better rearing habitat for anadromous salmonids in this part of the watershed.

The effects of the Flow Proposal on salmonid habitat were evaluated relative to the salmonid habitat conditions that would occur under D1610 for *all* and *dry* water supply conditions and for current and buildout water supply demands. The daily flow, temperature and DO levels that would occur under both flow management scenarios were scored based on the criteria presented in Appendix C. The frequency of scores for the different scenarios were then tabulated for the comparison. The comparison focused mainly on the summer months (June through October) when project operations would have the greatest effect on habitat. The conditions during the other times of year were evaluated as well, but habitat conditions during the wetter months (November through May) would generally be much more similar between the Flow Proposal and D1610.

Under the Flow Proposal, flows in the upper and middle Russian River during June through October under *all* water supply conditions would decrease relative to D1610 by 45 to 80 cfs. Under *dry* water supply conditions, flows in the upper and middle Russian River would increase over D1610 by 5 to 30 cfs. At buildout under *all* water supply conditions, flows under the Flow Proposal would be 10 to 35 cfs higher than at current demand levels, but would remain lower than those that would occur under D1610. Under *dry* water supply conditions at buildout, the Flow Proposal would result in flows 10 to 40 cfs higher than D1610. This would occur because the Flow Proposal balances water supply from the two reservoirs differently than D1610, to maximize habitat values in the Russian River and Dry Creek.

From November through May the flows in the upper and middle Russian River would be similar between the Flow Proposal and D1610 under both demand levels and both water supply conditions.

In Dry Creek, the Flow Proposal would provide lower summer flows than D1610 under all water supply conditions and demand levels. Summer flows would be 25 to 30 cfs lower under current demand levels for all water supply conditions. At buildout, the Flow Proposal would result in flows that are 35 to 50 cfs lower than D1610 under *all* water supply conditions, and up to 100 cfs lower during some months in *dry* water supply conditions. Under *critically dry* water supply conditions, which occurred during only one year in the 90-year simulation period (2 percent of the summer months), flows under the Flow Proposal could be as high as 200 cfs, but this would still be lower than flows under D1610 for dry water supply conditions (which occur about 15 percent of the time). Flows in Dry Creek in February and March under the Flow Proposal would tend to be 20 to 80 cfs higher than under D1610 for all water supply conditions. Under dry water supply conditions, the two management scenarios have similar flows February and March, and in April and May flows under the Flow Proposal would be higher, 50 cfs as compared to 25 cfs under D1610.

These changes in flow would result in improved water temperatures in the upper Russian River during September and October under the Flow Proposal under *all* water supply conditions. This would occur because the coldwater pool in Lake Mendocino would not be depleted as quickly. This difference in water temperature would diminish with distance downstream, and would not be significant at Healdsburg. In *dry* water supply conditions (which occur much less frequently), the Flow Proposal would result in warmer water temperatures in the upper Russian River. Again the difference between the water management scenarios decreases with distance downstream of Lake Mendocino.

In Dry Creek, water temperatures at the upper end of the stream would generally be quite similar between the two water management scenarios. In lower Dry Creek under the Flow Proposal, water temperatures would be increased over those with D1610, but would remain in the range considered generally acceptable for summer rearing. Winter temperatures would be similar for the Flow Proposal and D1610 for both water supply conditions and demand levels.

In the following sections, the effects of these changes in flow and temperature on the habitat for each species were summarized. Dissolved oxygen values were highly suitable for all lifestages of all species throughout the Russian River and Dry Creek under both water management scenarios and water supply conditions. DO is not discussed further.

5.7.3.1 Coho Salmon

Coho salmon spawn and rear in tributary habitat, including Dry Creek, but do not spawn or rear in the mainstem. The Flow Proposal was designed to improve habitat for coho salmon, and might positively affect coho spawning, rearing, and migration habitat in Dry Creek and migration in the mainstem.

Russian River

In the mainstem, the Flow Proposal and D1610 would result in similar flows during the coho salmon upstream migration period (November through January). Flows are predicted to provide good to optimal migration conditions about 75 percent of the time for *all* water supply conditions and 65 percent of the time for *dry* water supply conditions, reflecting the lower flows during migration periods. This would occur for both current and buildout demand levels. Water temperatures would be suitable for migrating adult coho salmon 90 percent of the time.

Dry Creek

The most substantial benefit to coho salmon under the Flow Proposal would be an improvement in summer rearing conditions in Dry Creek. Summer rearing conditions would improve markedly with lower flows in the summer and fall (June through October), especially at buildout demand levels. The Flow Proposal would provide good to optimal rearing flows 90 to 95 percent of the time under *all* and *dry* water conditions. As summer habitat conditions are thought to be one of the primary limiting factors for coho populations, these improvements could help reduce the summer population bottleneck.

Higher flows in Dry Creek in January under the Flow Proposal would slightly improve upstream migration and spawning conditions near Warm Springs Dam. In lower Dry Creek at buildout demand, lower flows under the Flow Proposal would provide better spawning conditions than D1610.

Water temperatures in Dry Creek would be suitable for all life-history stages under both water management scenarios. The only exception would be that the median summer rearing temperatures in lower Dry Creek would be warmer than 15º C more frequently under the Flow Proposal, but would not reach highly stressful levels (warmer than 16º C).

5.7.3.2 Steelhead

The primary areas for steelhead spawning and rearing that might be affected by the Flow Proposal would be the Upper and Middle reaches of the mainstem and Dry Creek. The Upper, Middle, and Lower reaches of the mainstem and Dry Creek were evaluated for migration. Rearing could also occur in, and near, the Estuary.

Russian River

The primary benefit of the Flow Proposal in the Upper Russian River, which has the best mainstem habitat, would be to improve steelhead summer rearing habitat by reducing summer flows relative to D1610 and decreasing water temperatures during the late summer and early fall. Median flows in the Russian River under the Flow Proposal would be from 50 to 150 cfs lower than D1610 during the summer rearing months during *all* water supply conditions, but as much as 50 cfs higher during *dry* water supply conditions. From November through May, flows would be similar between the Flow Proposal and D1610.

Overall, flow-related summer rearing habitat for steelhead would be very good to optimal about 30 percent more often under the Flow Proposal than D1610 under *all* water supply conditions. Under the Flow Proposal, good flows would occur for steelhead rearing 85 percent of the time throughout the Russian River under both current and buildout demand levels. During *dry* water supply conditions, D1610 would provide lower flows during the summer months and thus, slightly better rearing flows than the Flow Proposal. However, both management scenarios would provide good rearing flows about 90 percent of the time throughout the mainstem under *dry* water supply conditions.

These flow changes during June through October under the Flow Proposal would result in a substantial reduction in water temperature in the Upper Russian River relative to D1610 during September and October, with a smaller reduction in August. The Flow Proposal is predicted to produce slightly warmer median water temperatures in the upper mainstem in June and July. Near Ukiah, suitable water temperatures are predicted to occur about 10 to 15 percent more often under the Flow Proposal than D1610 under *all* water supply conditions, while under *dry* water supply conditions, the reverse would be true. Water temperatures increase with distance downstream from Coyote Valley Dam, but temperatures remain below 21°C to Cloverdale. At Healdsburg, median temperatures exceed 22º C from June through September under both management scenarios and both water supply conditions. Such temperatures would likely be stressful to rearing steelhead.

Flows for spawning and incubation are similar for the Flow Proposal and D1610. These flows are generally too high, and are considered unfavorable for these lifestages at both demand levels and water supply conditions, although they are somewhat better under *dry* water supply conditions. Spawning and incubation would occur with the same success as they do currently. Predicted water temperatures under the Flow Proposal and D1610 do not differ significantly during the upstream migration, spawning, and incubation periods, regardless of water supply conditions or water demand. During these periods, temperatures under the Flow Proposal and D1610 are suitable throughout the mainstem, but potentially lethal temperatures may occur about 5 to 10 percent of the time from Healdsburg to the Hacienda Bridge (primarily in April and May). During *dry* water supply conditions, incubation temperatures are slightly less favorable above Cloverdale. The Flow Proposal and D1610 would provide similar temperature conditions for these steelhead lifestages.

Dry Creek

Reduced flows in Dry Creek would provide a substantial benefit to rearing steelhead during the summer months. Under D1610, flows would often be too high, especially at buildout demand level under *all* and *dry* water supply conditions. Under the Flow Proposal, flows would be moderated, thereby increasing the amount of suitable habitat for juvenile steelhead. Summer rearing scores increase from predominantly 1 and 2 under D1610 to predominantly 4 and 5 under the Flow Proposal for both current and buildout demand level. Under the Flow Proposal, good-to-optimal habitat conditions would be provided about 90 percent of the time. Under *dry* water supply conditions, flows increase for both the Flow Proposal and D1610 at buildout, but to a substantially larger extent under D1610, resulting in less favorable flow conditions for juvenile steelhead. Under the Flow Proposal during *dry* water supply conditions, flows would be good about two-thirds of the time and stressful for the remainder of the time, with conditions better at the downstream end of Dry Creek than immediately below Warm Springs Dam. With D1610, flows would be unsuitable most of the time under *dry* water supply conditions at buildout.

Flow conditions during the adult upstream migration period are similar under both water management scenarios. In the upper portion of Dry Creek, the Flow Proposal provides higher flow and better migration conditions under *all* water supply conditions, but D1610 provides better habitat under *dry* water supply conditions because it has fewer days with flows that would block migration.

Habitat conditions for steelhead spawning would be similar for D1610 and the flow proposal under *all* water supply conditions at current demand levels, with suitable spawning flows occurring 50 to 65 percent of the time. At buildout demand levels, the Flow Proposal would provide slightly worse spawning conditions. Flows would be less favorable about 4 percent more often. Under *dry* water supply conditions, the Flow Proposal would provide good spawning conditions about 85 percent of the time as opposed to 66 percent of the time under D1610 at both current and buildout demand levels.

In upper Dry Creek D1610 provides better incubation conditions because flow would be lower under *all* water supply conditions. Under *dry* water supply conditions, the Flow Proposal provides better overall conditions for incubation with many scores shifting from good to optimal due to higher flows in April and May. In lower Dry Creek the Flow Proposal and D1610 result in similar incubation conditions regardless of water supply condition or demand level.

For both the Flow Proposal and D1610, water temperatures in Dry Creek near the dam tend to be cool and constant because release water would be managed to meet temperature requirements of the DCFH. Although water temperatures increase in a downstream direction, they remain good to excellent for most lifestages. Both management scenarios provide similar temperature conditions for all lifestages.

Summer rearing is thought to be the lifestage most limiting to steelhead production in the Russian River watershed. During summer water temperatures are warm and flows in most of the tributary streams are low due to natural runoff patterns and some water diversions. The increase in summer rearing habitat in the upper and middle Russian River and Dry Creek that would be provided by the Flow Proposal may appreciably increase the likelihood of survival, by reducing oversummer mortality. Through greater survival, larger numbers of steelhead smolts will reach the ocean and may return as adults to spawn, contributing to recovery of steelhead.

5.7.3.3 Chinook Salmon

The Flow Proposal would affect Chinook salmon habitat in the mainstem Russian River downstream of Coyote Valley Dam and Dry Creek. Chinook salmon use the Lower Reach of the Russian River as a migration corridor. Spawning, incubation, and rearing habitat for Chinook salmon occurs in the Upper and Middle reaches of the mainstem and in Dry Creek. Chinook salmon are generally present in the river system from October through June, but are absent during the warm summer months when project operations have the largest effects on flow and water temperature. Flows in the mainstem Russian River would generally be influenced more by natural runoff than by project operations during the time when Chinook salmon would be present in the river. The exception would be during the early upstream migration period, August through October.

Russian River

Under the Flow Proposal, migration conditions for adult Chinook salmon would be improved relative to D1610 because elimination of summertime artificial breaching of the sandbar at the mouth of the estuary would prevent adult Chinook salmon from entering the river in August and September, when flow and temperature conditions would likely be unsuitable. Adult Chinook would remain in the ocean until river flows increase. This would result in a large temperature benefit to these salmon during upstream migration and also make upstream passage easier at shallow riffles, reducing migration delays while in the river. This would be particularly true under *dry* water supply conditions. However, this might also expose these fish to greater predation by marine mammals and sport fishing while in the ocean.

Conditions for Chinook salmon spawning and incubation would be similar under the Flow Proposal and D1610 for each water supply condition and demand level. Flows during this period would generally be higher than optimal, due to runoff from unregulated tributaries. Either management scenario would provide good spawning conditions about 40 percent of the time and stressful spawning conditions about the same proportion of the time under *all* water supply conditions and poorer scores during *dry* water supply conditions.

Flows for incubation would be poor about 60 percent of the time under either scenario at both demand levels. Flows for incubation would be improved during *dry* water supply conditions, providing good to optimal habitat 55 percent of the time.

Flows during the Chinook rearing period (February through June) would also be similar between the Flow Proposal and D1610. These flows would be higher than optimal for young Chinook salmon due to natural runoff. Habitat conditions would have high velocities about 75 percent of the time under *all* water supply conditions. Habitat conditions would be improved in the later portion of the season over those in the early part of the season. Reduced flows in *dry* water supply conditions would improve habitat conditions relative to *all* water supply conditions. Good to optimal rearing habitat would occur about 40 percent of the time, while marginal conditions (scores ≤ 1) would occur about 15 to 30 percent of the time.

Water temperatures for juvenile rearing, incubation, and spawning would be similar under both water management scenarios. These temperatures would be good to optimal for these lifestages 75 to 90 percent of the time. Predicted temperatures for rearing would generally be favorable in the Upper Reach. Water temperatures would increase in a downstream direction, but even at the Hacienda Bridge they would generally be good when Chinook salmon are in the system. Suboptimal water temperatures for rearing and emigration would occur in the Lower Reach in June.

Water temperature conditions for adult migration would be improved under the Flow Proposal. By managing the Estuary as a closed system, migrating adults would not be exposed to higher water temperatures associated with low flows in August and September. In general, the frequency of poor and marginal water temperatures would decline from over 40 percent under D1610 to about 7 percent under the Flow Proposal.

Dry Creek

The Flow Proposal would provide slightly better rearing conditions for Chinook salmon in Dry Creek relative to D1610, under *all* water supply conditions, and would provide very good habitat conditions about 60 percent of the time. D1610 would result in corresponding conditions about 10 percent less frequently. Very good conditions would occur about twice as frequently under the Flow Proposal than D1610 under *dry* water supply conditions.

The Flow Proposal and D1610 would provide similar conditions for Chinook salmon upstream migration, spawning, and incubation. Good to optimal flows for upstream migration would occur 85 to 95 percent of the time under *all* water supply conditions. Under *dry* water supply conditions, flows would be slightly better for upstream migrants under D1610, but both management scenarios would provide good to optimal flows a large proportion of the time. For spawning, both the Flow Proposal and D1610 would provide very good conditions about 85 percent of the time under *all* water supply conditions and more than 90 percent of the time under *dry* water supply conditions. Similarly, good conditions would occur under both scenarios for Chinook incubation.

Temperatures would generally be highly suitable for Chinook salmon rearing throughout Dry Creek under both the Flow Proposal and D1610. In upper Dry Creek, both management scenarios would provide very good water temperatures (8 to 17°C) all of the time. In lower Dry Creek, some warmer temperatures (up to 20°C) would occur under both scenarios, with D1610 resulting in a slightly lower frequency of warmer temperatures. At buildout, temperatures would improve slightly in lower Dry Creek for D1610. About 5 percent more days received a score of 4. Scores remained the same under the Flow Proposal.

5.7.3.4 Low-Flow Estuary Management

The Low-Flow Estuary Management proposal would result in a more stable ecosystem that would improve summer rearing habitat over conditions under D1610. The proposed action would allow a freshwater-dominated system to develop, stabilize water quality, improve primary productivity and the invertebrate foodbase, and stabilize marsh and shoreline vegetation. The species most likely to benefit would be steelhead, although coho and Chinook salmon juveniles might also benefit. Because inflow to the Estuary would be managed so that the sandbar would generally close after peak downstream migration periods, downstream passage would not be substantially affected, although spring or early summer sandbar closures could occur in dry years. Reduced inflow to the lagoon might result in reduced dilution of nutrients or pollution, but would be not expected to affect salmonids.

By managing WSE at approximately 7 feet or less during the dry season, the probability of unauthorized breaching by local community members would be reduced, thereby reducing potential negative effects related to breaching.

5.7.3.5 Storm-Flow Estuary Management

Artificial breaching would still be required to manage storm flow in the spring or fall, and in some dry winters, to prevent flooding of adjacent property. Artificial breaching would occur at the onset of the rainy season and would be scheduled as closely as possible to the time when a natural breach might occur. Under baseline conditions, artificial breaching allowed early adult Chinook salmon to enter the river when river conditions could be unsuitable. Under the proposed project, the sandbar would be breached when river conditions are more suitable, which would also reduce the potential for incidental angling pressure or poaching in the River. Chinook would be exposed to predation and sport fishing in the ocean before entering the river.

Late-season breaching, which would occur after a late spring storm, might be of concern in dry years if, after the storm, river flow rapidly decreases to a low level. In this case, insufficient river flow might result in a long period of time passing before the lagoon would be freshened. Under the proposed management program, inflow to the lagoon would be managed so that it would freshen the lagoon early in the season and to maintain stable, suitable habitat conditions through the summer.

5.7.4 Channel Maintenance

5.7.4.1 Central Sonoma Watershed Project and Mark West Creek Watershed

Under the proposed project, channel maintenance activities would continue to be conducted on specific constructed flood control channels and natural waterways (see Tables 3-12 and 3-14) to maintain flood capacity.

The risk of direct effects to fish would continue to be low during these activities because they generally would occur during the summer, protocols would be implemented to minimize injury to fish or sedimentation to habitat, and fish rescues would be conducted, if necessary. Indirect effects to habitat would be more likely to occur than direct effects.

Sediment Removal in Constructed Flood Control Channels

Sediment removal activities may have negative, direct effects on a few individual juvenile coho salmon, steelhead, or Chinook salmon. Disturbance to the streambank would be kept to a minimum, unless significant sediment had accumulated along the banks. Effective sediment control practices would be used during instream work in wetted channels. Channels would be assessed by SCWA biologists before sediment removal activities are performed; in the rare instance that listed species would likely be present, a barrier would be established to exclude fish and, if necessary, rescue would be performed. To date, barriers and fish rescues have not been necessary (S. White, SCWA, pers. comm. 2003c).

The channels that would require the most sediment maintenance are the low-gradient channels in the Rohnert Park-Cotati area. Many of these streams have limited spawning or rearing habitat due to low summer flows, high summer water temperature, and heavy silt loads. Because sediment-laden, constructed flood control channels do not generally provide rearing habitat for coho salmon or steelhead, few, if any, fish would be present, so the risk of injury to fish would continue to be low. While some individual fish might be exposed to injury, but there would be a low risk to any of the populations of listed fish species as a whole.

However, sediment maintenance might occur in channels that are migration corridors to upstream spawning or rearing habitat. Sediment removal could result in the loss of a low-flow channel that develops within some of the flood control channels, which could impede upstream and downstream migration at low flows.

Vegetation Maintenance

Under baseline conditions, vegetation has been maintained at the original design maintenance level to maintain hydraulic capacity (flood control) and to reduce fire dangers. Under the proposed project, vegetation maintenance practices would be conducted at three levels: the original design maintenance level, and two additional levels that would allow riparian vegetation to develop, the intermediate or mature riparian vegetation maintenance levels. These two levels would result in increased canopy cover in some channels. Under the proposed project, hydraulic capacity assessments would be conducted to determine the level of flood capacity needed, and this information would be used to reevaluate the level of vegetation maintenance needed. Some streams that currently receive greater levels of vegetation clearing could potentially be managed at a level that would allows more vegetation to develop.

Because most flood control channels that require frequent or extensive maintenance do not provide good quality spawning and rearing habitat, only fish passage would be affected. The risk to the overall population of coho salmon, steelhead, and Chinook salmon would be relatively small, because, generally, few individuals would be using flood control channels.

Effects would be of greater significance for those flood control channels in tributaries that support rearing and/or spawning habitat in their upstream portions. Channels that may potentially support summer salmonid rearing habitat upstream of the maintained area, but may require the original design maintenance scenario, include Paulin, Piner, Santa Rosa, Brush, Copeland, Crane, Laguna de Santa Rosa, Rinconada, and Todd creeks. For segments of these nine channels, implementation of the original design maintenance practices may have localized effects on rearing and/or migration habitat.

Vegetation Maintenance in Natural Waterways

For the natural waterways where vegetation removal might occur, SCWA does not have routine or regularly-implemented maintenance obligations. SCWA would remove vegetation on these other natural waterways only where there are site-specific problems with flood capacity. Therefore, the length of vegetation removal would be limited to small projects, generally 300 to 600 feet long.

While individual projects may be small, the sum of several projects may have larger effects, especially if they occur in important salmonid spawning and rearing habitat such as some of the natural waterways in Mark West Creek and its tributaries. Therefore, removal of instream and streambank vegetation would be kept to a minimum in these streams (i.e., only where significant flood control hazards or threats to structures exist). Vegetation removal in streams with limited rearing habitat (for example, some natural waterways in the Rohnert Park area) would not be as likely to diminish salmonid habitat, and therefore could safely be more extensive. Proposed vegetation removal activities, therefore, have a relatively low risk of short-term or long-term indirect effects to salmonid habitat (particularly coho salmon and steelhead) in natural waterways.

Debris Removal

Large woody debris would not likely play a significant role in providing structure or habitat in flood control channels, given the limited tree resources and recruitment processes. Therefore, the SCWA practice of limiting large woody debris removal to situations when it poses a flood control hazard would likely not result in substantial reduction of cover or scour. Because large woody debris is currently scarce in the flood control channels, restoration actions that would promote the planting or growth of native trees or that install instream structures that provide some of the functions of large woody debris would improve habitat for rearing or spawning, or (in the case of constructed flood control channels) for migration.

Flood Control Reservoirs

Four flood control reservoirs would continue to act to passively reduce flooding in the Santa Rosa area during the rainy season. Three of these are onstream reservoirs with minimum streamflow bypasses. These three reservoirs would continue to act as barriers to upstream migration for anadromous coho salmon and steelhead. A diversion structure on Spring Creek would also impede upstream migration.

Maintenance activities in the reservoirs would not affect salmonids directly. While there would likely be an increase in water temperatures in Santa Rosa Creek when Spring Lake is drained, this effect would be unlikely to exceed thresholds that would affect salmonid survival because water would be released as early as possible in the spring.

Only a small drainage area is captured by the Brush Creek, Piner Reservoir, and Spring Creek diversion facilities (although water from 2.3 miles of Spring Creek are diverted), so peak floods probably would not be significantly altered and resulting downstream effects probably would not be significant. Matanzas Creek Reservoir generally fills and spills after mid-December, so channel maintenance flow events would likely pass to the natural downstream reach later in the year. Because most of Santa Rosa Creek downstream of Spring Lake has been altered for flood control, attenuation of peak flows would not negatively affect the geomorphology of the creek.

Sediment and large woody debris retention on Brush Creek, Piner Reservoir, and the diversion on Spring Creek are low because these facilities are small, so effects to downstream habitat would likely be minimal. The capacity of Matanzas Creek reservoir is larger, so retention of spawning gravel in the reservoir may affect downstream spawning habitat. However, spawning habitat would be limited by other issues related to the geomorphology of the channel rather than by a lack of spawning gravel. While some spawning gravel may be retained in the reservoir, the risk to the populations of listed fish species would continue to be low.

When predators from Spring Lake would be released during high-flow events, they would not introduce a new risk. The additional fish passing downstream may help to maintain the local population of predators. The risk of predation would not be increased, but may be sustained.

The most significant effect of the flood control reservoirs would be the potential entrapment of anadromous salmonids into Spring Lake. Because good-quality spawning and rearing habitat occurs upstream of the diversion, it would be expected that some individual coho salmon, or more likely, steelhead, may be trapped. However, there would not be a long overlap between juvenile salmonid migration periods and the time water spills to Spring Lake. Water flows to Spring Lake about one day per year, so the risk to the populations of coho salmon, steelhead and Chinook salmon would be low.

5.7.4.2 Warm Springs and Coyote Valley Dam Projects in Dry Creek and Russian River

SCWA and MCRRFCD would continue to maintain the bank stabilization works installed as part of the Warm Springs Dam and the Coyote Valley Dam projects in Dry Creek and the mainstem Russian River, respectively. Activities would be limited to maintenance of existing structures. Most of these sites are in stable condition and would not require work in the near future. Effects would generally be limited to small-scale effects related to sediment input to the creek and some small amount of vegetation removal. Use of effective BMPs would reduce the risk of short-term effects. Therefore, both the short-term, direct effects to fish and long-term habitat effects would be low.

5.7.4.3 Gravel Bar Grading and Vegetation Maintenance for Bank Stabilization in the Russian River

In the mainstem Russian River, gravel bar grading and vegetation maintenance would continue to be conducted by two different agencies, the MCRRFCD and SCWA, each in their respective counties, to control bank erosion. Sediment maintenance work would consist of grading gravel bars and creating overflow channels during the dry summer season.

Because the work would occur in dry channels and gravel bars, direct effects to fish, and also sedimentation to aquatic habitat, would likely be minimal or nonexistent. Gravel bar grading and vegetation maintenance could however, have long-term effects to salmonid habitat. Steelhead and Chinook salmon use the mainstem for spawning, rearing, and migration.

Under the proposed project, these activities would be more limited than those conducted historically. No more than four bars (four in Sonoma County and four in Mendocino County) would receive maintenance in any one year, and the length of any one site would not exceed 1,000 feet. Gravel bar grading and vegetation removal on bars would be scheduled in rotation over a course of 3 to 5 years, so that high-flow velocity refuge areas for salmonids (river meanders, pools, and vegetation) would develop and be maintained at some bars in any given year. Protocols would be implemented to preserve a buffer zone, grade the channel to minimize the risk of stranding fish during flow recessions, and preserve large woody debris. Although habitat would be altered at any one site in a year, the limitations under the proposed project are designed to ensure that sufficient, good-quality habitat would remain in the mainstem over time.

5.7.4.4 Emergency Bank Stabilization in Natural Waterways

Emergency sediment removal and bank stabilization work would occasionally be required in natural waterways after a large storm event, at landowner request and pursuant to approved contracts with the landowners.

Sediment removal and channel clearing activities have the potential to injure or kill fish. SCWA intends to reduce this risk by excluding fish from the work area with barriers or relocating them, if necessary.

Potential habitat alterations that may occur due to sediment removal in natural waterways include loss of shade canopy and cover, and loss of hydraulic and associated habitat diversity. The potential for habitat alterations due to sediment maintenance and bank stabilization in natural waterways to populations of coho salmon, steelhead, and Chinook salmon would continue to be small. This is due to the infrequent need for maintenance activities in natural waterways; the prescriptions for limiting the size of any one project to 1,000 feet; and the guidelines for incorporating bio-engineering, revegetation, and fish habitat elements into bank stabilization work.

5.7.4.5 Gravel Bar Grading in the Mirabel/Wohler Area

SCWA would continue to augment infiltration capacity for its water distribution system in the Mirabel and Wohler area by periodically grading gravel bars in the river in the area of diversion to increase infiltration in the river.

There would be no risk of direct injury to migrating juvenile salmonids during this activity at the Wohler, Bridge, and McMurray bars (upstream of the inflatable dam). The potential to injure juvenile steelhead at Mirabel would be slightly greater because steelhead may be trapped in the Mirabel Bar. Fish rescues would reduce the risk to a low level.

The potential to alter habitat with sediment input from instream activities would be addressed through use of BMPs. When gravel bars are graded, streambed sediments would be disturbed. During the first rainstorm, loose sediments might be mobilized, which could result in short-term increases in turbidity. Because these gravel bars are located in the lower river, sediments would probably not be deposited in primary spawning or rearing habitat. The overall risk for injury and habitat degradation would be low.

5.7.4.6 NPDES Permit Activities

Overall, the permittees have determined that the NPDES permit plans and associated activities have been effective. Chemical and biological monitoring results since 1998 indicate that no consistent trends or specific water quality constituents of concern have been identified (City of Santa Rosa, Sonoma County Water Agency, County of Sonoma, 1998, 1999, 2000). Bioassay results indicate very low toxicity of stormwater from sampled runoff events. Indirect indicators, including number of inspection and enforcement actions; amount of educational materials distributed; and amounts of pollutants removed through maintenance, spill response, and implementation of BMPs, indicate that the SWMP has been successful to date. NPDES permit plan activities would have a beneficial effect on listed species and their critical habitat.

5.7.5 Restoration and Conservation Actions

SCWA has implemented, funded, or planned projects designed to benefit listed species and their habitat in the Russian River watershed. These efforts include restoration projects (riparian and aquatic habitat protection, restoration and enhancement, fish passage); watershed management; support for state and federal recovery planning for coho salmon; restoration of the Riverfront Park property; and water conservation and reuse.

Collectively, most of these projects would have a substantial beneficial effect on the habitat of the listed fish species. Some types of restoration and conservation actions are likely to affect individual fish during construction activities, but there would continue to be no risk to populations of listed species as a whole. However, the lakes in the Riverfront Park property have the potential to entrap salmonids when floodwaters recede.

5.7.5.1 Funding and Priorities

SCWA commits substantial funds, staff, and equipment to restoration projects. Additionally, in-kind contributions of staff and equipment have been committed to restoration projects. Additional grant money has been, and would continue to be, pursued.

To maximize the effectiveness of the dollars invested, SCWA would continue to develop project priorities on a basin-wide level, and in cooperation with CDFG and other agencies and private interests in the watershed. SCWA would continue work to implement priorities and recommendations formally outlined by CDFG. Partnerships with other stakeholders in the watershed have been instrumental to the success of SCWA restoration projects and programs. SCWA would expand the indirect beneficial effects of restoration projects by taking advantage of opportunities for public education associated with the restoration projects.

5.7.5.2 Restoration Actions and Fish Passage Projects

Typically, larger projects provide more biological benefits than smaller projects. Conservation and restoration actions were evaluated quantitatively by assessing their *biological benefit*. The biological benefit score was based on the project size (length of stream affected), the time frame for expected benefits, habitat elements affected and their relative importance to listed fish species, stream inventory and/or population data, the cost vs. benefits of the project, and the educational value of the project.

Actions that are part of the proposed project include restoration on 16 different streams, affecting more than 50 miles of streams. Steelhead are the most abundant species in many of these areas, but as coho salmon populations are recovered, use of these streams by these species would likely increase. All projects listed would likely improve habitat for spawning, rearing, and migration of listed salmonids. BMPs to minimize negative effects are generally outlined during the permitting process.

The primary benefit of fish passage projects would be the additional spawning and rearing habitat that would become available to anadromous salmonids. The Mumford Dam modification project provides unrestricted access to approximately 45 miles of spawning and rearing habitat in the mainstem Russian River upstream of the Forks. This benefits steelhead and Chinook salmon and possibly coho salmon. This project also improves approximately 600 feet of habitat directly downstream of Mumford Dam. The improvements in Santa Rosa Creek in the Hood Mountain region improve access to approximately 10 miles of upstream habitat, which benefits coho salmon and steelhead.

SCWA is restoring property that was previously used for gravel mining to a public park. The lakes in the Riverfront Park area have the potential to entrap salmonids when floodwaters recede. Salmonids have a risk of being entrained, as one of these events occurs approximately every 1 to 2 years. The park property is located in the Lower Russian River, and adult and juvenile salmonids of all three listed fish species may be affected.

5.7.5.3 Water Conservation and Reuse

Water reuse and conservation are expected to reduce peak water demand approximately 3 to 5 percent. This would typically occur during the dry season in mid-summer. Water conservation is expected to help meet future, growing water demands, and may help to reduce the amount of water diverted from streams tributary to the Russian River.

5.7.5.4 Watershed Management Projects

Scientific research efforts, information dissemination, and regional coordination of management efforts are important components of the restoration and conservation of listed species and their habitat. Data on population trends and habitat use will help focus conservation actions where they will have the greatest effect. Genetic data are critical to decisions regarding artificial propagation, as well as providing insights to the long-term viability of existing populations. By sharing information and coordinating restoration actions with other groups, limited resources are focused so that the maximum number of beneficial effects can be realized.

5.7.6 Proposed and Future Fish Production Programs

The DCFH and CVFF have been operated under established mitigation and enhancement goals for coho salmon, steelhead, and Chinook salmon. Under the proposed project, a conservation hatchery program would be implemented for coho salmon to aid in their recovery. The isolated harvest program for steelhead would continue, with an option for a future integrated harvest program. Chinook salmon production would be halted, with an option for a future integrated supplementation program.

5.7.6.1 Coho Salmon

The main objective of the captive broodstock and supplementation programs for the Russian River is to prevent extirpation of Russian River coho salmon. Given the low numbers of coho salmon, it is clear that the Russian River spawning aggregate is at risk of extinction. A properly maintained and managed supplementation program, as begun by CDFG's Russian River pilot captive broodstock program implemented in 2001, would be invaluable as a means to avoid further genetic degradation of the Russian River aggregate. It would also increase coho salmon populations in the Russian River and provide a buffer against demographic risks of low adult returns.

Potential risks to the Russian River coho salmon population associated with the proposed hatchery programs include reduction of genetic viability in coho salmon stock, competition with hatchery-produced coho salmon or steelhead, and predation by hatchery steelhead. By using local coho salmon stocks as the source of broodstock and implementing a carefully crafted breeding program, the captive broodstock and supplementation programs can substantially reduce the risk of loss of genetic diversity. New rearing techniques, including low-density rearing conditions and the use of NATURES features, would reduce artificial selection, improving the fitness of hatchery outplants. Potential competitive interactions among naturally-spawned coho salmon and coho salmon from the captive breeding program would be reduced by releasing coho salmon into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population.

5.7.6.2 Steelhead

The proposed steelhead isolated harvest program would contribute toward mitigation requirements and sustain a recreational steelhead fishery while minimizing effects on listed fish populations. As with the coho salmon program, hatchery protocols would be implemented to minimize genetic and ecological risks to the naturally-spawning steelhead population. Appropriate broodstock sampling and mating protocols would be implemented. Programs that rear fish through the smolt life-stage have a higher risk of artificial selection than those that release smaller fish. As described for coho salmon, new rearing techniques would reduce the risk of artificial selection. To reduce possible effects related to potential competitive interactions or predation, the hatchery program would release steelhead smolts in the same size range as wild smolts, and volitional release and acclimation would help reduce straying.

A future alternative integrated harvest program, which would use wild steelhead broodstock rather than only hatchery-reared fish, would significantly reduce the risk of genetic effects to the naturally-spawning population. The integrated harvest program may be implemented, if needed, to protect genetic integrity of steelhead in the Russian River. Potential benefits may also include reduction in short-term risk of extinction and increase in speed of recovery. By increasing the abundance of native steelhead, a vital component of the ecosystem would be restored. However, factors responsible for the original decline must be addressed.

5.7.6.3 Chinook Salmon

This BA currently proposes a “no production” program. Based on the current short-term abundance data for Chinook salmon, the Russian River spawning aggregate of the California Coastal Chinook ESU does not appear to be at immediate genetic risk, and indeed, it may be a self-sustaining population. This suggests that the “no production” alternative may result in the least genetic effect to the remaining Russian River Chinook salmon population.

A supplementation program could be implemented if population trends indicate that this action is needed to prevent the Russian River population of Chinook salmon from declining below the viable population threshold. Potential benefits of future supplementation programs include reduction in short-term risk of extinction, increase in speed of recovery, and restoration of ecosystem processes. By increasing the abundance of native Chinook salmon, a vital component of the ecosystem would be restored. Supplementation could help speed recovery through increased population abundance for Chinook salmon. However, factors responsible for the original decline (if one exists) must be addressed.

The loss of within-population diversity and outbreeding depression may be minimized by appropriate broodstock sampling and mating protocols. For the proposed future supplementation program, approved protocols for broodstock sampling and mating would be implemented. The future Chinook salmon program would incorporate new rearing techniques to reduce artificial selection, low-density rearing, and volitional-release programs to reduce competition and predation pressures on the local naturally-spawning population. Fish would be released into locations where the habitat capacity exceeds the requirements of the naturally-spawning population.

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